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Joint EPA-EPRI (Environmental Protection Agency-Electric Power Research Institute) Cold Weather Plume Study (CWPS) Overview of Measurements and Data Base

Washington Univ., St. Louis, MO

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COLD WEATHER PLUME STUDY (CWPS)

Overview of Measurements and Data Base

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ABSTRACT

The Cold Weather Plume Study (CWPS) was a field measurement program carried out in February 1981 under the joint sponsorship of the U.S. Environmental Protection Agency and the Electric Power Research Institute. Its objective was to generate a data base suitable for quantitative analysis of the mesoscale physical dynamics and SO_x, NO_x chemistry of the plume of the 1320 MW coal-fired Kincaid power plant near Springfield, IL. The data base was intended to complement similar measurements made by other EPA and EPRI studies in the same region during other seasons. Measurements included in-situ chemical measurements from two instrumented aircraft, remote-sensing lidar measurements from an aircraft, meteorological measurements from a surface station, two met towers, and from vertical soundings. This report provides a brief overview of the measurement platforms, the measured parameters, and the daily experiments, and describes and documents the data base available on magnetic tapes and in hard copy form.

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CONTENTS

Abstract iii
List of Tables vi
List of Abbreviations vii
Acknowledgments vii
Executive Summary viii

1. INTRODUCTION 1

2. SUMMARY OF CWPS MEASUREMENTS 2
   2.1 In-situ Aircraft Sampling 2
   2.2 Meteorological Measurements 8
   2.3 Aircraft Lidar Measurements 11
   2.4 Stack Sampling 11

3. CWPS MISSIONS 12

4. CWPS DATA BASE 19
   4.1 Hard Copy Data Base of CWPS 21
   4.2 GDDB of CWPS on Magnetic Tapes 21

APPENDICES

A1. EMI, MRI AIRCRAFT FLIGHT OUTLINES AND MAPS 24
   A1.1 EMI Aircraft 25
   A1.2 MRI Aircraft 41

A2. GDDB FILES, THEIR CONTENTS AND FORMATS 52
   A2.1 Listing of Files in GDDB-CWPS 53
   A2.2 Partial Listing of Contents of Data Files of 2/13/81 55
   A2.3 Documentation STATE-20 and STATE-VS File Formats 68

LIST OF TABLES

Number

2.1 EMI Aircraft Instrumentation

2.2 MRI Aircraft Instrumentation

2.3 MRI Aerosol Size Distribution Measurements

2.4 MRI Integrated Sample Collections and Analyses

2.5 Rockwell Source Emissions and Meteorological Measurements

2.6 Locations and Schedule of AV Upper Air Soundings

3.1 Summary of Aircraft Missions

3.2 Summary of Participation of Platforms for 12 February 1981

3.3 Summary of Participation of Platforms for 13 February 1981

3.4 Summary of Participation of Platforms for 14 February 1981

3.5 Summary of Participation of Platforms for 16 February 1981

3.6 Summary of Participation of Platforms for 20 February 1981

4.1 Summary of Measurements and Data Base of CWPS

4.2 Catalog of Files in the GDDB of CWPS

4.3 Listing of the Daily Summary Files of GDDB

LIST OF ABBREVIATIONS

AV	=	AeroVironment Inc.
Battelle	=	Battelle Columbus Labs
EMI	=	Environmental Measurements, Inc.
EPA-LV	=	Environmental Protection Agency, Las Vegas
EPA-RTP	=	Environmental Protection Agency, Research Triangle Park
EPRI	=	Electric Power Research Institute
ISWS	=	Illinois State Water Survey
MRI	=	Meteorology Research, Inc.
NWS	=	National Weather Service
Rockwell	=	Rockwell International
SRI	=	SRI International

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EXECUTIVE SUMMARY

A Cold Weather Plume Study (CWPS) was carried out from a St. Louis base in February, 1981 under the joint sponsorship of the Environmental Protection Agency (EPA) and the Electric Power Research Institute, Inc. (EPRI). The main objective of the field measurement program was to generate a data base appropriate for quantitative characterization of the mesoscale transport and chemical transformations of SO_x and NO_x in the plume of the 1320 MW, coal-fired Kincaid power plant near Springfield, IL, under winter conditions. The measurements included in-situ airborne chemical sampling in the plume and its background, as well as a variety of meteorological measurements characterizing the PBL structure and dynamics of the wind, temperature and humidity fields. Previous extensive power plant plume measurements had been carried out in power plant plumes in the same region in summer and spring periods. Analyses of the data of these previous studies had already yielded valuable quantitative empirical descriptions of the plume atmospheric transmission processes, particularly for SO_x. A more specific objective of the winter study was to test the validity of such quantitative parameterizations under winter conditions and, if necessary, to revise the formulations to make them seasonally more general. Another important aspect of the winter study was a more balanced emphasis on SO_x as well as NO_x atmospheric chemistry. This report overviews the measurement program, identifies other reports which contain more detailed program description and data, and most importantly, describes and documents the formal overall centralized data base of CWPS.

There were two teams of participating groups in the field program, one supported by EPA and the other by EPRI. Each participating group had a specific role in the study, yet all measurements of a given daily mission were performed within the context of a co-ordinated overall mission plan. The two teams shared the same overall program objectives, but emphasized different specific objectives. The EPA team's focus was more on SO_x chemistry, while the EPRI team placed greater emphasis on NO_x chemistry. Overall, the measurement strategy was focused on detailed aircraft chemical sampling in the plume over a mesoscale range; two primary sampling aircraft were typically deployed in each experiment. Supporting measurements included stack sampling, monitoring of ambient meteorological parameters, and remote sensing of PBL aerosol structure and dynamics.

The participating groups and their principal roles are outlined below:

EPA Team

EPA - RTP	: technical direction
EPA - LV	: airborne lidar measurements
EMI	: program planning; in-situ
	: aircraft measurements
AV	: field program management;
	: meteorological support
SRI	: meteorological support
WU	: on-site data processing and review;
	: program data management;
	: data interpretation

EPRI Team

BATTELLE	: program planning;
	: on-site organic sample analysis;
	: MRI aircraft instrumentation for NO_x and HNO_3;
	: data management for EPRI team;
	: data interpretation
MRI	: in-situ aircraft measurements
ROCKWELL	: Stack sampling;
	: meteorological support

The in-situ aircraft measurements included continuous monitoring of gas concentrations (SO_2, NO, NO_x, N_{Total}, O_3), aerosol parameters (ANC, Charge, B_{scat}), meteorological variables (temperature, humidity, pressure, turbulence, solar radiation), and navigational parameters (altitude, VOR, DME). Integrated filter samples were collected and analysed for aerosol sulfate, nitrate, chloride and ammonium; for gaseous ammonia and nitric acid; and for elemental composition. Automatic bag samples were also collected nearly instantaneously at regular intervals and analysed on-line for aerosol size distribution. In addition, integrated samples were collected in Teflon bags and analysed daily at a ground laboratory for detailed speciation of organic vapors, including PAN.

Stack measurements of SO_2, NO, O_2 and exit gas velocity and temperature were made at Kincaid. Meteorological support measurements included measurements near the power plant by ROCKWELL, and at downwind locations near prevailing plume transport trajectory by AV. Measurements near the power plant were made at a surface station (pressure, temperature, net/solar/sky radiation, cloud cover and precipitation), from 10 and 100m meteorological towers (mean temperature, dewpoint, wind speed/direction, and u,v,w components of the wind field), and from tracked T-sondes (T, wind speed/direction). Downwind meteorological measurements by AV included frequent pibal (wind speed/ direction) and airsonde (temperature and relative humidity) soundings during the experiment periods. Synoptic weather data were gathered

and interpreted by SRI at the local NWS forecasting office. SRI provided weather forecasts and summaries tailored to the needs of the daily missions.

PBL and plume structure and dynamics were "visualized" by remote sensing of atmospheric aerosol distribution based on lidar returns of aerosol backscattering monitored in the lidar aircraft (EPA-LV) flying well above the PBL.

The Kincaid power plant has two generating units rated at 660 MW each, both feeding into a single 187 meter tall stack. During the CWPS period, however, one of the units was inoperative.

The field study period was 9–21 February, 1981. During this period, a total of six independent field experiments were carried out on five separate days (February 12, 13, 14, 16 and 20). There were two separate experiments on the 20th. In four of these experiments, both primary sampling aircraft (EMI and MRI) performed co-ordinated measurements. In three separate missions, the two aircraft flew side-by-side to provide data for cross-comparison. The first three experiments were conducted under very cold daytime winter conditions. Ambient conditions were unseasonably warm during the last three experiments. One of these experiments was during the night. During the first and the last experiments, the Kincaid plume was sampled within the convective daytime mixing layer; bulk plume transport was in the stable layers aloft during all other sampling missions. Plume background was fairly clean during all field missions.

Each participating group was responsible for quality assurance, post-processing, and validation of its own data. The final data of the EPA team was centralized at the WU-ME Special Studies Data Center at Washington University in St. Louis. The data of the EPRI team was centralized at Battelle, Columbus Labs. The EPA and EPRI data bases were formally exchanged in 1984. Subsequently, both these subsets of the overall data base were reformatted and standardized into a single unified CWPS data base at our data center. All data files in this CWPS data base conform to the standard STATE formats common also to three other data bases of major EPA-sponsored Studies (MISTT, Tennessee Plume Study, and PEPE-NEROS). This report provides a full documentation of the final CWPS data base. Future distribution of the data base will be administered by EPA.

1. INTRODUCTION

Electric power generating stations using coal and oil as fuel constitute a major source of SO_x and NO_x emissions into the atmosphere of the eastern United States. Atmospheric transmission processes (transport, transformation, removal) acting on these emissions determine their atmospheric residence time, their contribution to ambient air pollution, their range of transport, location of impact, and form of deposition. In the past decade, many field studies have been carried out with the objective of quantitative investigation of the mechanisms and rates of the atmospheric transmission processes. The vast majority of these field measurements were carried out during the summer season when the chemical transformation processes leading to the formation of noxious secondary products from the precursor emissions are more rapid and secondary pollutant levels (air concentrations and depostions) are more pronounced. Such summer field studies include the EPA-sponsored Projects MISTT (St. Louis, 1974–1976) and STATE-Tennessee Plume Study (Tennessee, 1978), and the EPRI-sponsored SURE Plume Study (Indiana, Michigan, Mississippi, 1977) and the Plume Model Validation Study (PMV: Kincaid, IL, 1980). In February 1981, EPA and EPRI jointly sponsored the field program of the Cold Weather Plume Study (CWPS). The measurements of this study were made in plume of the Kincaid power plant.

EPA's principal objectives in the interpretation of the CWPS data included characterization of winter transport of tall-stack plumes, the quantitative assessment of mechanisms and rates of SO_2-to-sulfate conversion in power plant plumes in winter, and the testing of an empirical parameterization of plume sulfur conversion rate originally formulated based on summer data. EPRI's prime objectives were to study the details of the NO_x chemistry of the plume during near-field transport, to test a detailed reactive plume model, and to extend the simple-terrain short-range plume dispersion study of PMV to broader seasonal coverage. Such data analyses have been carried out at WU for EPA and at BATTELLE for EPRI.

Two detailed reports describe the CWPS measurement program: one is by EMI (EMI, 1984)*, the EPA prime contractor for CWPS; the other is by BATTELLE (Battelle, 1983), the EPRI prime contractor for CWPS. Both describe the full range of CWPS measurements, but each is focused more on activities of its respective team. Since these reports adequately cover the details of the measurement program, platforms, data processing and validation, quality assurance, etc., this report contains only a brief program overview and a description and documentation of the final data base. Five hard copy data volumes, one for each of the five mission days of CWPS, were prepared in conjunction with this report. Each data volume contains a daily meteorological summary, and graphical plots of complete meteorological and aircraft data (EMI and MRI). The daily data volumes thus collectively contain a compilation of almost all the available data of CWPS in graphical or tabular form. The data volume contents are described further in chapter four, "CWPS Data Base".

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* References are listed in section 4.1.

2. SUMMARY OF CWPS MEASUREMENTS

2.1 In-situ Aircraft Sampling

Two instrumented aircraft performed in-situ plume and background measurements. They were the EMI and the MRI aircraft. Tables 2.1 and 2.2 summarize the instrumentation packages of the two aircraft. The common parameters monitored in the continuous mode in the two aircraft were: SO_2, NO/NO_x, O_3, Aitken nuclei count, aerosol charge, light scattering coefficient (B_{scat}), ambient and dew point temperatures, aircraft altitude and the VOR/DME position co-ordinates. In addition, the MRI aircraft also monitored broadband and UV solar radiation from an upward-looking sensor, and small-scale atmospheric turbulence (expressed in terms of the turbulent energy dissipation rate, ϵ). The MRI NO_x chemiluminescence analyzer was specially modified by BATTELLE to measure NO, NT (=NO + NO_2 + HNO_3 + NO_3 + $2N_2O_5$ + PAN), and NO_x(=NT−HNO_3). The difference (NT−NO_x) is reported in the data base as HNO_3. The EMI aircraft also had a fast response sulfur monitor specially modified to monitor continuously the particulate sulfur component (S_p). The instrument operation, performance, and data for S_p have, however, been judged of unacceptable quality, and have been excluded from the data base. The absence of acceptable S_p data is a critical shortcoming of the chemical data base of CWPS. Another critical shortcoming of the CWPS data of EMI was due to the malfunction of the nephelometer (B_{scat}) in the first three EMI missions (Feb. 12, 13, 14). A replacement was in place for the last two experiments (Feb. 16, 20) and performed well. The data logger in the MRI aircraft malfunctioned in the first mission (Feb. 12). However, most of the continuous data were recorded on strip charts and were later digitized and incorporated into the permanent data base.

The two aircraft also made some aerosol size distribution measurements. The EMI aircraft had an electrical aerosol analyzer (EAA, for .0032 to 1 μm size range) and a ROYCO optical particle counter (OPC for .56-5.6 μm range). The data of these measurements have not been processed and are not available in the current data base. The MRI aircraft instrumentation package for aerosol size distribution measurements is summarized in Table 2.3.

Both aircraft also collected some time-integrated samples for post-facto chemical analyses. The EMI integrated sampling included a cyclone separator system for collection of fine aerosols (<3 μm), and a tungstic acid tube system for collection and later analysis of gaseous and particulate ammonia and nitric acid. The filter sampling of aerosols was on washed nylon filters (analysed for sulfate and nitrate), and on prepared cellulose nitrate filters (analysed for chloride). The integrated sample collections and analyses pertinent to the MRI aircraft sampling are outlined in Table 2.4. They include bag samples for hydrocarbons and PAN, and filter samples for inorganic gaseous and aerosol species.

Table 2.1 EMI Aircraft (Chem-1) Instrumentation Summary for CWPS. (Taken from EMI, 1984, Table 3.1)

Category	Parameter	Instrument Make and Model	Nominal Operating Range	Sensitivity	Response Time (sec)
Air Quality Continuous Analyzers	O_3	CSI 2000	0-200 0-500ppb	3%	1
	SO_2	Meloy 285 FR and Hydride Cylinder	0-500ppb depending on distance. 0-100ppb 0-50ppb	1ppb	3
	NO/NO_x	Monitor Labs 8440E modified for fast response	0-500ppb depending on distance. 0-200	3ppb	1
	$SO_4^{=}$, H_2SO_4	Meloy 285 FR modified for SO_2 scrubbing and aerosol heating	0-50ppb	1ppb	3
	b_{scat}	MRI 1567 modified for aircraft.	$0-10x10^{-4}m^{-1}$	$0.1x10^{-4}m^{-1}$	2
	Aitken nuclei	Environment One Aitken Nuclei Counter modified for high pressure inlet.	0-100k CN/ml	3k CN/ml	5
	Electronic Aerosol Analyzer	Thermo-Systems, Inc.	.0032-1 micron		Time integrated.
	Aerosol Charge Acceptance	Washington Univ.	0.01-0.1micron		1
	Optical Particle Counter	Royco 220	0.56-5.6micron		Time integrated/

continued on next page

Table 2.1 (Continued) EMI Aircraft (Chem-1) Instrumentation Summary for CWPS. (Taken from EMI, 1984 , Table 3.1)

Category	Parameter	Instrument Make and Model	Nominal Operating Range	Sensitivity	Response Time (sec)
Air Quality Integrated Samplers	$SO_4^=$, NO_3^- Cl^-	cyclone filter pack			
	Gaseous-Ammonia and Nitric Acid Particulate-Ammonium and Nitrate.	Tungstic Acid hollow tube preconcentrator (Univ.of S.Florida)			
Meteorology	Temperature	Type J thermocouple	-300 to +300°F	0-1°C	2
	Dewpoint	General Eastern 1110	-40 to 49°C	±0.5°C	3
Data Acquisition	all	Fluke 2240		-40 to +40V	1 scan/2 sec.
Position	VOR	King KN53	0-360°	±1°	5
	DME	King KN62A	0-50 n.mi.	±0.1 n.mi.	1
	Altitude	Aeroeonic	feet msl	± 50 ft.	0

Table 2.2 MRI Aircraft (Queen Air) Instrumentation Summary for CWPS. (Taken from BATTELLE '83, Table 4.2)

Parameter	Sampler Manufacturer and Model	Analysis Technique	Normal Measurement Ranges (Full Scale)	Time Response (to 90%)	Approximate Resolution
SO_2	Meloy 285	Flame Photometric	100, 500, 1000 ppb	30 s	1 ppb
NO/NO_x HNO_3	Monitor Labs 8440	Chemiluminescence Modified by BCL	200, 500, 1000 ppb	5 - 10 s	<5 ppb
O_3	Monitor Labs 8410	Chemiluminescence	500 ppb	5 s	5 ppb
Light Scattering	MRI 1569	Integrating Nephelometer	10^{-4} and 10^{-3} m^{-1}	<1 s	10^{-6} m^{-1}
Condensation Nuclei	Environment One Rich 100	Light Attenuation in an Expansion Chamber	10^5 cm^{-3}	3 s	10^3 cm^{-3}
Aerosol Charge Acceptance	Washington University	Aerosol Charge Acceptance	Primarily responds to .01 - .1μ particles	~1 s	--
Broad Band Radiation	Eppley PSP	Pyranometer	0 - 1026 w/m^2 Cosine response	1 s	2 w/m^2
Ultraviolet Radiation	Eppley	Barrier-Layer Photocell	295 - 385 mμ 0 - 34.5 w/m^2 Cosine response	1 s	0.1 w/m^2
Turbulence	MRI 1120	Pressure Fluctuations	0 - 10 $cm^{2/3}$ s^{-1}	3 s (to 60%)	0.1 $cm^{2/3}$ s^{-1}
Temperature	YSI/MRI	Bead Thermister/ Vortex Housing	-55° to +45° C	5 s	0.5° C
Dew Point	Cambridge Systems 137	Cooled Mirror	-50° to +50° C	0.5 s/° C	0.5° C
Altitude	Validyne	Absolute Pressure Transducer	0 - 3000 m msl	1 s	6 m
Indicated Airspeed	Validyne	Differential Pressure Transducer	23 - 68 m s^{-1}	1 s	0.1 ms^{-1}
Position	Xing KX170B/ HTI DVOR	Aircraft DME/VOR	0 to 359° and 0 to 150 km from the station	1 s	1° (bearing), 0.2 km (distance)
Data Logger (includes time)	MRI Data System	9-Track Tape - 6 hour capacity in continuous operation	±9.99 VDC	Records data once per second	0.01 VDC
Stripchart Recorder	Linear Instruments	Dual Channel	0.01, 0.1, 1, 10 VDC	<1 s	--
Printer	Axiom	--	80 character lines	Prints out data every 10 seconds and at every event code or data flag change	

Table 2.3 Aerosol Size Distribution Measurements on Queen Air. (Taken from BATTELLE '83, Table 4.3)

Instrument	Size Range	Method
TSI 3030[a]	0.006-0.56	Aerosol Charger/Mobility Analysis
PMS ASASP-X[b]		
Range 3	0.090-0.195	Optical Particle Counter Illumination in Laser Cavity and 35° to 120° Collection
Range 2	0.15-0.30	
Range 1	0.24-0.84	
Range 0	0.60-3.0	
PMS FSSP-100[b]		
Range 3	0.5-8	Forward Scattering Spectrometer Probe
Range 2	1-16	
Range 1	2-32	
Range 0	2-47	

[a]Automatic bag sampling system for TSI 3030; bagfill takes place in about 3 seconds and occurs automatically every 5 minutes or on command.

[b]The Particle Measuring Systems (PMS) optical particle counters can be manually set to any range, or can be set to automatically cycle through the ranges with 1 second in each range.

Table 2.4 Integrated Sample Collections and Analysis for Queen Air. (Taken from BATTELLE '83 Table 4.4)

Determination	Collection Medium	Particle Size Segregation	Nominal Flow Rate (lpm ambient)	Analysis Method
PAN C_1-C_{10} Hydrocarbons	Teflon bags	None	<1 (ram flow)	Cryogenic preconcentration/ gas chromatography
$SO_4^=$, NO_3^-	2 µm Zefluor 47 mm	Bendix 240 cyclone (2.5 µm cut)	50	Ion chromatography
Elemental Carbon	Pallflex Quartz 47 mm	Bendix 240 cyclone (2.5 µm cut)	20	GRALE: C light absorption
Elemental Composition	2 µm Teflo 25 mm	Bendix 240 cyclone (2.5 µm cut)	40	X-ray fluorescence
Total Inorganic Nitrate HNO_3 as NO_3^-	1 µm Zefluor/1 µm prewashed nylon 47 mm	None	30	EC-GC
Ammonia	2 µm Zefluor/oxalic acid impregnated glass fiber	None	10	colorimetry
Elemental Composition	2 µm Teflo after filter	Impactor (50% cut at 4, 2, 1, and 0.5 µm)	10	PIXE

The sampling missions and times for the two aircraft are summarized in Table 3.1. Each aircraft had five flight missions, four being common to both aircraft. During three of these common missions (viz. February 12, 16, 20), single-traverse, side-by-side and simultaneous flights were made by the two aircraft for the purpose of inter-comparison of data. Data plots showing such inter-comparison of common continuous monitors are included in the EMI data volume (EMI, 1983).

2.2 Meteorological Measurements

Meteorological support for the program was provided by three organizations: ROCKWELL, AV and SRI. ROCKWELL's measurements were made at a surface station, from 10 m and 100 m meteorological towers, and from vertical soundings, all at a site about 1 km east of the Kincaid power plant. The ROCKWELL measurements and instrumentation are outlined in Table 2.5. The vertical soundings were based on T-sondes which were tracked by double theodolites, and which measured vertical profiles of temperature and wind speed and direction.

Solar radiation is, of course, a crucial parameter for data analyses, for both dispersion and chemistry interpretations. The only radiation data collected directly under CWPS auspices were at the ROCKWELL surface station at Kincaid, and the continuous measurements of UV and broadband radiation in the MRI aircraft. Unfortunately, good surface data were obtained only on February 20. Consequently, a substitute set of total radiation data for the mission days was obtained in the form of continuous strip chart recordings made at the Illinois State Water Survey (ISWS) facility in Champaign, IL, about 80 km to the northeast of Kincaid. The ISWS solar radiation data for each day were digitized by us, and have been incorporated into the CWPS data base.

AV provided additional upper air soundings for the wind, temperature and humidity vertical profiles in the PBL. A mobile minisonde platform was used to launch pilot balloons equipped with pressure, temperature and relative humidity sensors. By tracking the pilot balloon from a single theodolite, vertical profiles of horizontal wind speed and direction were also determined. The AV minisonde was located at a different downwind fixed site under the plume trajectory for each mission. The site was typically about 40–60 km downwind of Kincaid, the actual location being selected based on the prevailing wind data obtained from the ROCKWELL soundings which commenced shortly before the start of the aircraft mission. The AV site locations and pibal launch periods are summarized in Table 2.6. Further details of the AV measurements and data are contained in the AV data volume (AV, 1983).

SRI provided meteorological support pertaining to synoptic and local weather review and forecasting tailored to the daily mission needs. An experienced weather forecast meteorologist, utilizing the extensive resources of the local NWS weather forecast office in St. Peters, MO, (near St. Louis) monitored the weather conditions and provided frequent weather bulletins and forecasts to guide mission planning and execution. Some of the raw materials (weather maps, etc.) used by SRI are included in our daily data volumes (appended to this report). Also included in those data volumes are 3-hourly tabulations of pertinent data collected at the NWS surface weather

Table 2.5 Source Emmissions and Meteorological Monitoring During CWPS. (Taken from BATTELLE '83, Table 4.5)

Variable	Number of Measurement Locations	Frequency of Measurements	Equipment or Method Used
Source Emissions			
SO_2 and NO	Stack	Continuous	Lear Siegler SM810
O_2	Stack	Continuous	Lear Siegler CM50
Velocity	Stack	Continuous	Kurz 455 (Hot Wire)
Temperature	Stack	Continuous	Kurz 455
Meteorological			
100 m Tower			
Wind Direction	10 m, 30 m, 50 m, 100 m	Continuous	Teledyne Geotech 15658
Wind Speed	10 m, 30 m, 50 m, 100 m	Continuous	Teledyne Geotech 15648
Temperature, T	10 m-50 m; 10 m-100 m	Continuous	Teledyne Geotech T-200
uvw Winds (Gill)	100 m	Continuous	R. M. Young 27004
Dewpoint	100 m	Continuous	Teledyne Geotech OO-200
10 m Tower			
Temperature, T	2 m-10 m	Continuous	Teledyne Geotech T-200
Surface Station			
Atmos. Pressure	1	Hourly	Teledyne Geotech 5P-100
Cloud Cover	1	Hourly	Visual Observations
Precipitation	1	Hourly	Teledyne Geotech PG2 OOH
Surface Temperature	1	Continuous	Barnes PRT-S
Net Radiation	1	Continuous	Science Associates 622-1
Solar Radiation	1	Continuous	Eppley NIP
Sky Radiation	1	Continuous	Eppley 8-48

[a]Adapted from Table 3-1, Reference 3.

Table 2.6 AV Airsonde Launch Schedule. (Taken from AV, 1983)

Date	Location	Launch Period LST
2-12-81	Rock Springs Center, Decatur, ILL	1215 - 1225
		1308 - 1316
		1404 - 1414
		1533 - 1535
		1626 - 1632
2-13-81	Mount Pulaski, ILL	0838 - 0849
		0939 - 0952
		1046 - 1051
		1144 - 1158
		1243 - 1254
		1340 - 1354
		1443 - 1457
		1543 - 1554
		1642 - 1651
2-14-81	Boody, ILL	1249 - 1303
		1339 - 1347
2-16-81	Decatur Airport, ILL	1129 - 1141
		1243 - 1257
		1338 - 1352
		1441 - 1455
		1536 - 1549
		1632 - 1646
		1744 - 1759
2-20-81	Pana, ILL	0252 - 0308
		0346 - 0401
		0444 - 0500
		0539 - 0553
		0644 - 0658
		0733 - 0748
		0935 - 0948
		1032 - 1047
		1131 - 1145
		1233 - 1246
		1332 - 1346

observation stations in about a 100 km radius of Kincaid.

2.3 Aircraft Lidar Measurements

A two-frequency (I.R. and Green), downward-looking, airborne lidar system was flown and operated by EPA-LV. The aircraft lidar typically flew at about 3 km altitude in a pattern of cross-plume traverses at several downwind arcs. In normal operation, the lidar emitted laser pulses downward and the return signal, representing aerosol backscattering, thus provided a measure of aerosol distribution below. The return signals were recorded on magnetic tapes. The data provide vertical profiles of aerosol concentration (at 3 m vertical resolution) at approximately 10 m horizontal resolution. The lidar data provide a visual depiction of the PBL and plume aerosol structure and dynamics with broad spatial coverage.

The lidar aircraft flew missions on all five days. The lidar data complement the other aircraft data of all experiments except the last one during daytime on February 20.

2.4 Stack Sampling

ROCKWELL performed continuous stack sampling for stack SO_2, NO and O_2, as well as continuous monitoring of stack exit temperature and velocity. The single 187 m stack at Kincaid has an inner diameter of 9.0 meters. The measurements and instrumentation for stack sampling are summarized in Table 2.5. The data are included in the CWPS data base.

3. CWPS MISSIONS

CWPS experiments were conducted on five separate days, viz. February 12, 13, 14, 16 and 20. Table 3.1 summarizes the times, prevailing atmospheric conditions, and aircraft mission times for EMI, MRI and EPA-LV aircraft for all five days. The EMI aircraft flew on all five days; The MRI aircraft did not fly on February 14, but flew a complete predawn mission on February 20 (the only night mission of CWPS) preceding their full daytime mission on the same day. The lidar aircraft flew all missions except the daytime mission of February 20. Plume transport was mostly in the elevated stable layers in all but the first and the last experiments (February 12 and 20 daytime experiments). In these two leading and trailing experiments, the plume was well-mixed within the convective daytime mixing layer. Plume background during all but one of the experiments was fairly clean and dry. On February 16, the PBL air became very hazy and foggy during the course of the experiment. However, except for a possible brief period of entrainment of a portion of the plume into the upper portion of the mixing layer on this day, the bulk of the plume transport was outside the very polluted mixing layer.

Typical winter conditions did not prevail during the entire CWPS period. During the first week (including the experiments of Feb. 12, 13, 14), the ambient conditions were colder than average for this time of year with snow on the ground. The second week (including Feb. 16 and 20), however, was unseasonably warm, with daytime ground level temperatures peaking above 15 C (59°).

Aircraft missions of the five days are summarized in the form of flight outlines and maps for the two in-situ aircraft, in Appendix A1. Table 3.2 summarizes the participation of all platforms for all days. All times in the CWPS data base are in Central Standard Time (CST).

Table 3.1 Summary of Plume Missions EMI, MRI and Lidar Aircraft.

DATE	MISSION CONDITIONS	SAMPLING PERIOD EMI	MRI	LIDAR
2/12	Well-mixed, daytime plume Ground snow cover (T_o = 12°F @ 0900) Fairly clean background	0945-1430	1300-1845	1130-1345
2/13	Stable, daytime plume Ground snow cover (T_o = 9°F @ 0700) Fairly clean background	0745-1600	0900-1530	900-1515
2/14	Stable, daytime plume Melting snow (T_o = 15°F @ 745)	0745-1500	-	915-1530
2/16	Elevated, daytime plume Very warm day (T_o > 60°F in PM) Humid near ground Relatively hazy day	1300-1730	1200-1915	1245-1600
2/20	Expt. 1: Stable, night-time plume	-	0315-0715	245- 430
2/20	Expt. 2: Well-mixed, daytime plume Very warm day (T_o > 60°F in PM) Clean air mass	1030-1415	0900-1400	-

TABLE 3.2

Summary of the Participation of All Platforms on February 12, 1981.

Organization and Type of Data	HOUR OF DAY																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
EMI in-situ aircraft										X	X	X	X	X	X									
MRI in-situ aircraft													X	X	X	X	X	X	X					
EPA - LV lidar												X	X	X										
Rockwell T-sonde					X			X		X	X		X		X	X	X							
AV pibal													X		X	X	X							
AV mini-sonde													X	X	X	X	X							
NWS (Springfield)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NWS (St. Louis, Peoria, Springfield)	X			X			X			X			X			X			X			X		
Illinois State Water Survey Solar Radiation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Rockwell Meteorological Tower	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Rockwell Stack	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MRI impactor													X	X	X	X	X	X	X					
MRI hydrocarbon													X	X	X	X	X	X	X					
MRI XRF													X	X	X	X	X	X	X					

TABLE 3.3

Summary of the Participation of All Platforms on February 13, 1981.

Organization and Type of Data	HOUR OF DAY																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
EMI in-situ aircraft								X	X	X	X	X		X	X	X								
MRI in-situ aircraft									X	X	X	X		X	X	X								
EPA - LV lidar										X			X	X	X	X								
Rockwell T-sonde						X	X		X	X	X	X		X	X	X								
AV pibal									X	X	X	X	X	X	X	X	X							
AV mini-sonde									X	X	X	X	X		X	X	X							
NWS (Springfield)									X	X	X	X	X	X	X	X	X							
NWS (St. Louis, Peoria, Springfield)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Illinois State Water Survey Solar Radiation	X			X			X			X			X			X			X			X		
Rockwell Meteorological Tower	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Rockwell Stack	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MRI impactor	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MRI hydrocarbon								X	X	X	X		X	X	X									
MRI XRF								X	X	X	X		X	X	X									
								X	X	X	X		X	X	X									

TABLE 3.4

Summary of the Participation of All Platforms on February 14, 1981.

Organization and Type of Data	HOUR OF DAY																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
RMI in-situ aircraft							X	X	X	X	X	X		X	X	X								
MRI in-situ aircraft																								
EPA - LV lidar										X	X			X	X	X								
Rockwell T-sonde					X		X	X	X		X	X	X											
AV pibal													X	X										
AV mini-sonde													X	X										
NWS (Springfield)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NWS (St. Louis, Peoria, Springfield)	X			X			X			X			X			X			X			X		
Illinois State Water Survey Solar Radiation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Rockwell Meteorological Tower	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Rockwell Stack	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MRI impactor																								
MRI hydrocarbon																								
MRI XRF																								

TABLE 3.5

Summary of the Participation of All Platforms on February 16, 1981.

Organization and Type of Data	HOUR OF DAY																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
EMI in-situ aircraft														X	X	X	X	X						
MRI in-situ aircraft													X	X	X	X	X	X						
EPA - LV lidar													X	X	X	X								
Rockwell T-sonde									X	X	X	X	X		X	X	X							
AV pibal												X	X	X	X	X	X	X						
AV mini-sonde												X	X	X	X	X	X	X						
NWS (Springfield)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NWS (St. Louis, Peoria, Springfield)	X			X			X			X			X			X			X			X		
Illinois State Water Survey Solar Radiation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Rockwell Meteorological Tower	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Rockwell Stack	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MRI impactor													X	X	X			X	X					
MRI hydrocarbon													X	X	X			X	X					
MRI XRF													X	X	X			X	X					

TABLE 3.6

Summary of the Participation of All Platforms on February 20, 1981.

Organization and Type of Data	HOUR OF DAY																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
EMI in-situ aircraft											X	X	X	X	X									
MRI in-situ aircraft				X	X	X	X	X			X	X	X	X	X									
ETA - LV lidar			X	X	X																			
Rockwell T-sonde	X		X	X	X	X	X	X	X	X	X	X	X	X										
AV pibal			X	X	X	X	X	X		X	X	X	X	X										
AV mini-sonde			X	X	X	X	X	X		X	X	X	X	X										
NWS (Springfield)	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
NWS (St. Louis, Peoria, Springfield)	X			X			X			X			X			X			X			X		
Illinois State Water Survey Solar Radiation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Rockwell Meteorological Tower	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Rockwell Stack	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
MRI impactor				X	X	X	X	X			X	X	X	X	X									
MRI hydrocarbon				X	X	X	X	X			X	X	X	X	X									
MRI XMF				X	X	X	X	X			X	X	X	X	X									

4. CWPS DATA BASE

The data base of CWPS is summarized in Table 4.1. The Table gives, for each measurement platform, the measured parameters, temporal resolution of the data when regular, and the form(s) in which the data are available. In general, the data base exists in two forms—on magnetic tapes and in the form of reports and hard copy data volumes.

The magnetic tape data base is in two parts—the aircraft raw data base, and the final GDDB (General Distribution Data Base). The GDDB is the standardized final user form of the data base on magnetic tapes. It includes all the validated data collected in CWPS except the aircraft lidar data, and the EMI and MRI aircraft aerosol size distribution data. The lidar data on tapes are in raw form only, very voluminous, and not expected to be of interest to most users of CWPS data. The lidar hard copy data volume contains a complete and easily usable photographic presentation of the data. Corresponding to each lidar plume traverse, two photographs (one for I.R. return and one for Green return) give the entire picture of aerosol spatial distribution in grey scale contrast. The aircraft raw data base includes the raw data of the lidar aircraft as well as of the two chemical sampling aircraft.

In what follows, we describe the hard copy data base and the GDDB of CWPS.

TABLE 4.1

JOINT EPA-EPRI COLD WEATHER PLUME STUDY (CWPS 1981)

SUMMARY OF MEASUREMENTS

WU/EPA Special Studies Data Center
Washington University
St. Louis, MO

Sponsor	Organization	Data Collecting Platform	Data Description		Archive Form & Availability	
EPA	EMI	Aircraft (Cessna 404)	5 Sampling Missions			
			Continuous Data: (2 sec.)	Time, VOR/DME, (LAT/LONG), altitude, temp, dew point, SO_2, NO/NO_x, O_3, B_{scat}, ANC, Aerosol charge, $SO_4^=$, H_2SO_4 (continuous sulfate data believed to be of unacceptable quality)	Mag tapes Data Volume	✓ ✓
			Aerosol Size Distribution:	EAA (Data not processed yet) OPC (Data not processed yet)	-	
			Other Samples:	Filter samples analyzed for $SO_4^=$, NO_3^-, NH_4^+ and NH_3, HNO_3	Tabulations in Data Volume	✓
				Grab samples analyzed for detailed HC speciation	Tabulations in Data Volume	✓
	AV	Pibals Minisonde	Discrete vertical soundings during mission days altitude, wind speed/direction, temp		Mag tape Data Volume	✓ ✓
	SRI	Weather Forecast and Analysis Support	Meteorological Summary Report		Report	✓
	EPA-LV	Aircraft Lidar	Continuous Data:	Time, location, ground speed, ground temp, dual frequency lidar return (aerosol backscatter) at 20 ft. intervals (10000 ft to ground level)	Mag tapes	✓
				Flight maps, photographic data plots	Data Volume	✓
	ILLINOIS (*) STATE WATER SURVEY (Champaign, IL)	Surface station	Total incident solar radiation		Data plots Mag tape	✓ ✓

(*) Collected independent of CWPS. ISWS broad-band radiation data received in stripchart form, and subsequently digitized at WU Data Center.

EPRI	MRI	Aircraft (Queen Air)	Continuous Data: (1 s.)	Time, location (Distance, heading from origin of each traverse), altitude, indicated air speed, temp, dew point, turbulence, UV & Broad-band Radiation, SO_2, NO, NO_x, HNO_3, O_3, Bscat, ANC, Aerosol Charge	Mag tapes Data Volume	✓ ✓
			Aerosol Size Distribution:	EAA, OPC, FSSP	Mag tapes	✓
			Other Samples: Filter Samples:	$SO_4^=$, NO_3^- (Ion Chromatography) Elemental (XRF & PIXIE) Composition Total Inorg. NO_3 (EC-GC) NH_3 (Colorimetry)	Mag tape	✓
			Bag Samples:	PAN, detailed HC speciation (GC)	Mag tape	✓
			5-min average data			
	ROCKWELL INTERNATIONAL	Source Monitoring	SO_2, NO, O_2, Stack exit velocity & temp		Mag tapes	✓
		Met tower (10 m) Met tower (100 m)	ΔT (2 m - 10 m) Wind speed/direction (10, 30, 50, 100 m) ΔT (10 m - 50 m, 10 m - 100 m) Dew point (100 m) u, v, w winds (100 m)		Mag tape	✓
		Surface station	T_o, Radiation (Total, net, sky - data good 1 day only)			
			Hourly data			
		Surface station	Atm. pressure, cloud cover, precip.		Mag tape	✓
		NWS Surface Obs. (Springfield)	Atm. pressure, T, dew point, wind speed/direction, ceiling height, cloud cover, precip.		Mag tape	✓

4.1 Hard Copy Data Base of CWPS

Besides this report and its appendices, there are two other detailed reports related to CWPS. They are:

1. EMI (July 1984): Cold Weather Plume Study, Final Report to EPA (Contract No. 68-02-3411)

2. Battelle, Columbus Labs (May 1983): Nitrogen Oxide Transformations in Power Plant Plumes, Interim Report to EPRI (Research Project 1369-2)

The above reports describe the EPA and EPRI portions of the field program in detail. There are three other Data Volumes also:

1. EMI (Dec. 1983): Cold Weather Plume Study, Chem I Data Volume

2. AV (June 1983): Cold Weather Plume Study, Upper Air Measurements, Report No. DO81-025

3. EPA-Las Vegas (Jan. 1982): Airborne Downward Looking Lidar Measurements During the Cold Weather Plume Study, Data Volume. EPA-EMSL, Las Vegas, TS-AMD-81088

The following report prepared by SRI International provides a descriptive summary of pertinent weather information for each day of the study, based on meteorological data and guidance that were collected by SRI at the NWS Forecast Office in St. Peters, MO. This report also includes selected maps and plots depicting radar summaries, satellite photos, airmass trajectories and the upper air data of the Peoria and Salem, IL upper air weather stations.

4. SRI (June 1983): "Meteorological Summary Report, Cold Weather Plume Study, St. Louis, MO." W. Viezee, SRI Project 1446 Report.

Finally, there are the five daily data volumes related to this report of Washington University (Appendices A3, A4, A5, A6 and A7). These data volumes present, mostly in graphical and partly in tabular form, the continuous data of both chemical aircraft (EMI and MRI) as well as the meteorological data of Rockwell, AV and NWS. These are the only data volumes which contain plots of the MRI aircraft data. Copies of these unpublished data volumes can be provided by either the principal author or the EPA Project Officer.

4.2 GDDB of CWPS on Magnetic Tapes

Table 4.2 summarizes the daily data base of GDDB in matrix form.

The data files are all in STATE-20 or STATE-VS formats. Documentation for these data formats is included in Appendix A2.3. The only data files in STATE-VS are the AV upper air (pibal and minisonde) data files and the Rockwell T-sonde data files.

The GDDB of CWPS is written on two 2400 foot long, 1/2-inch wide, industry-compatible, 9-Track magnetic tapes. The data packing density is 1600 bpi. Blocking within each file is fixed, and block length is 1600 bytes.* The tapes have no labels or ANSI standard volume and file labels. Each file on a tape is separated by a single end-of-file (EOF) mark, and two EOF marks follow the last file on the tape. The data are encoded in ASCII.

Tape 1 contains a total of 35 files comprising the data of February 12, 13, and 14. Thirty-two of these files are data files and three are daily summary files. Tape 2 contains a total of 27 files, 13 for February 16 (1 summary file and 12 data files) and 14 for February 20 (1 summary file and 13 data files). The data files are grouped by day, and a leader file for each day with the name SUMMARY.mdd (mdd = 212, 213, 214, 216, and 220) simply contains a listing of the data files in that day's data base. Each entry in the summary files gives the file name, organization collecting data, type of data, and file format.

A listing of the daily summary files is included in Appendix 2.1. Collectively, this listing is also a list of all the 62 files on the two tapes. This listing of files is followed by a partial listing of the contents of each of the 12 data files of 13 February 1981 (Appendix A2.2). For each file, the partial listing gives the full contents of the header and the comments sections, and in-between, the contents of a few data records at the beginning and end of the data section.

The partial file content listings in the Appendix are followed by the documentation of the STATE-20 and STATE-VS file formats (Appendix A2.3).

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* All data files have fixed 1600 byte blocks. The daily summary files (SUMARY.mdd), however, have maximum block size of 1600 bytes.

TABLE 4.2

CATALOG OF FILES IN THE GDDB OF CWPS

ORGANIZATION	DATA DESCRIPTION	FILENAME*	DATA COLLECTION DATE				
			12	13	14	16	20 (Feb.'81)
EMI	Aircraft continuous data	EMIA81.mdd	X	X	X	X	X
MRI	Aircraft continuous data	MRIA81.mdd	X	X	-	X	X**
MRI	Aircraft integrated sample data	MRIINT.mdd	X	X	-	X	X
MRI	Aircraft elemental analysis (PIXE) data	MRIPIX.mdd	X	X	-	X	X
MRI	Aircraft elemental analysis (XRF) data	MRIXRF.mdd	X	X	-	X	X
ROCKWELL	Met tower and surface data at Kincaid	R81MET.mdd	X	X	X	X	X
ROCKWELL	NWS surface weather data at Springfield	R81NWS.mdd	X	X	X	X	X
ROCKWELL	Stack sampling data	R81STK.mdd	X	X	X	X	X
AV	Pibal data	AV81PI.mdd	X	X	X	X	X
AV	Airsonde data	AV81AS.mdd	X	X	X	X	X
ROCKWELL	T-sonde data	R81TS.mdd	X	X	X	X	X

* The extension .mdd in the filenames identifies the date of the data in month and day, e.g. 212, 213, 214, 216 and 220

** There are two MRI continuous data files for 2/20/81 (one for each mission)

APPENDIX A1

EMI, MRI AIRCRAFT FLIGHT OUTLINES AND MAPS

This appendix contains credits for
References 37 and 39. These references
are BATTELLE, 1983 and EMI, 1983, respectively

APPENDIX A1.1

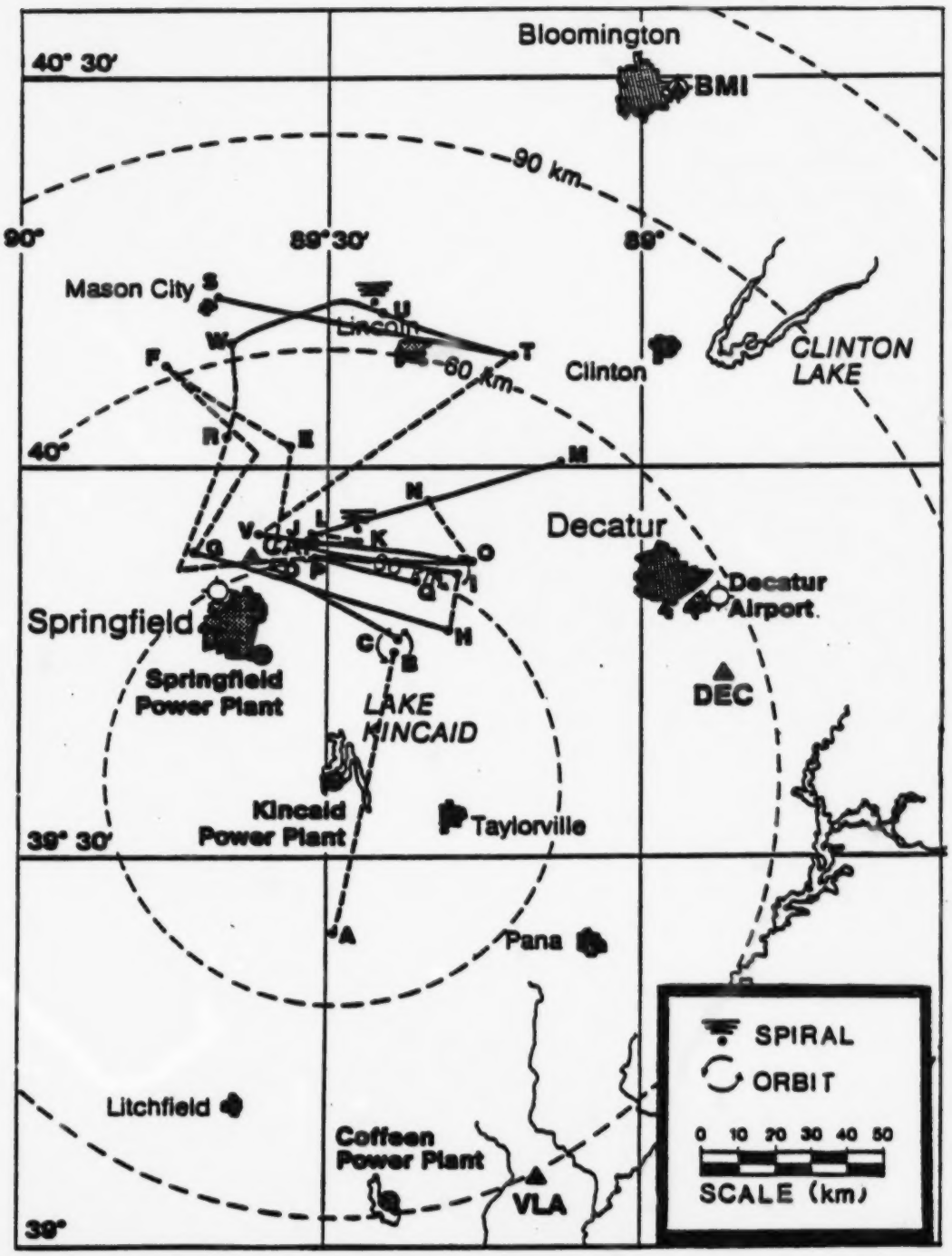
EMI AIRCRAFT FLIGHT OUTLINES AND MAPS

EMI Flight Outline for February 12, 1981.
(Taken from Reference 39, Table 5.1)

EVENT NO.	TYPE	TIME	ROUTE	ALTITUDE (m MSL)	COMMENTS; CYCLONE FILTER NO.
1	F	0920-0945	KSUS-A		No magnetic data
2	F	0945-0954	A-B	622-470	
3	O	0954-0959	B-C	470	SO_2 plume seen (Coffeen?) CF#15
4	T	0959-1003	C-D	470	
5	F	1003-1014	D-E-F	470	
6	F	1014-1026	F-G	470	
7	T	1026-1037	G-H	470	
8	F-O	1037-1043	H-I	470	
9	T	1043-1048	I-J	470	
10	F	1048-1054	J-K	470-318	
11	S	1054-1106	K	378-1540	CF#18
12	F	1106-1116	K-V-L	1540-683	
13	T	1116-1124	L-M	683	Probably outside mixing layer
14	F	1124-1134	M-N-O	549	
15	T	1134-1141	O-P	470	
16	T	1142-1146	P-Q	409	
17	T	1147-1152	Q-P	409	
18	F	1152-1200	P-R	409-927	
19	F	1200-1231	R-X	897-592	Bg CF#21

(Continued) EMI Flight Outline for February 12, 1981. (Taken from Reference 39, Table 5.1)

EVENT NO.	TYPE	TIME	ROUTE	ALTITUDE (m MSL)	COMMENTS; CYCLONE FILTER NO.
20	T	1231-1242	X-U-T	470	
21	T	1243-1254	T-S	561	
22	F	1254-1258	S-U	318	CF#23
23	S	1302-1307	U	318-927	Ozone instrument problem
24	F	1307-1314	U-S	927-278	Ozone instrument problem
25	T	1314-1325	S-T	409	Ozone instrument problem
26	F	1325-1343	T-V	409-836	Ozone instrument problem
27	T	1343-1350	V-O	439	No valid data after 134700
28	T	1351-1359	O-V	592	
29	T	1401-1409	V-O	683	CF#25
30	T	1410-1419	O-V	531	MRI flyby
31	F	1419- ?	V-KSPI		No continuous data CF#24
32	F	1540- ?	KSPI-KSUS		No continuous data



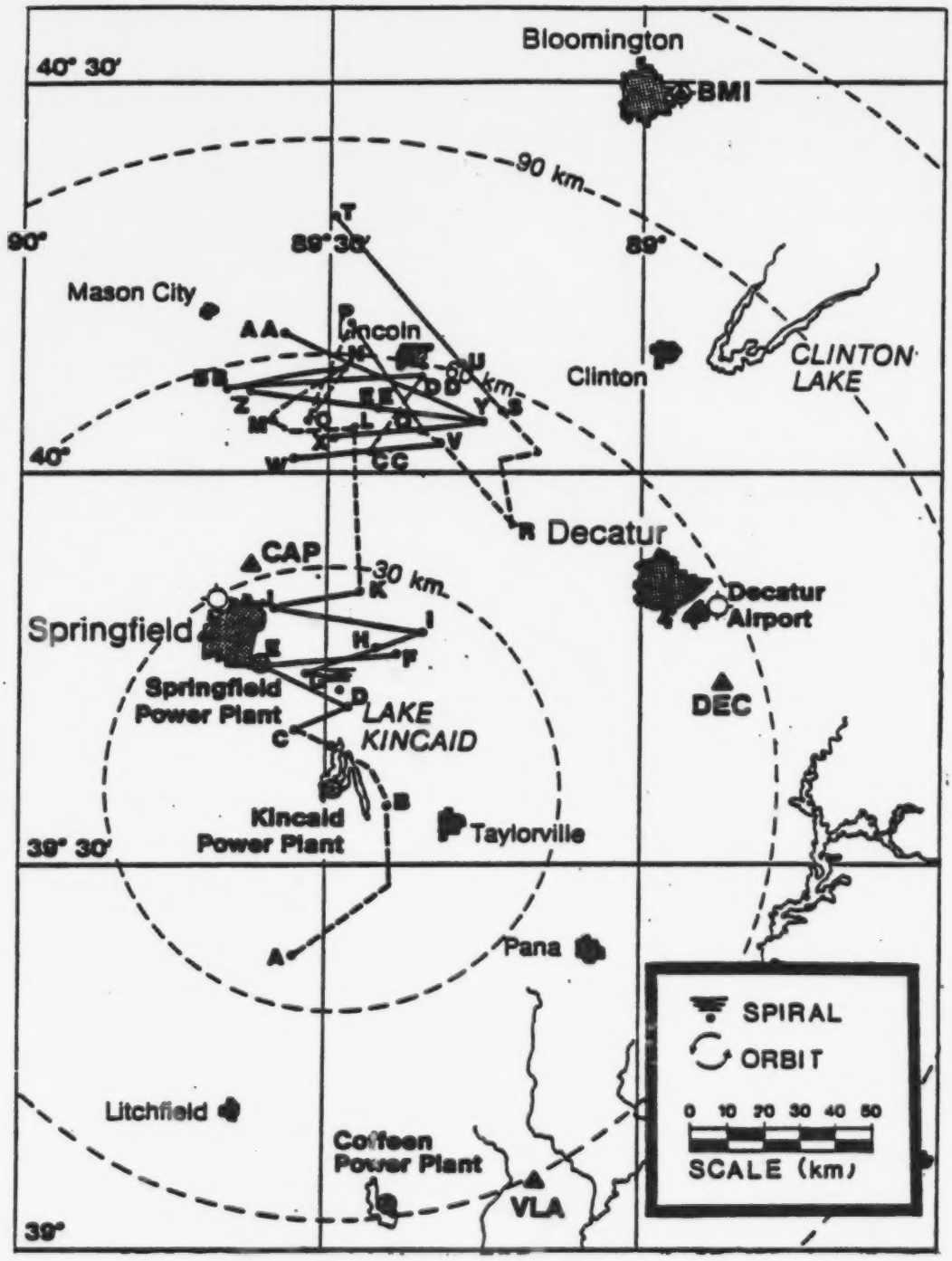
EMI Flight Map for February 12, 1981.
(Taken from Reference 39, Figure 5.1)

EMI Flight Outline for February 13, 1981, morning flight. (Taken from Reference 39, Table 5.2)

EVENT NO.	TYPE	TIME	ROUTE	ALTITUDE (m MSL)	COMMENTS; CYCLONE FILTER NO.
1	F	0746-0755	A-B	905	CF#17
2	F	0755-0802	B-C	783	
3	T	0802-0805	C-D	631	
4	T	0805-0810	D-E	631	
5	T	0810-0815	E-F	631	
6	T	0815-0821	F-E	631	
7	F	0821-0827	E-G	631-417	
8	S	0827-0832	G	417-1060	
9	T	0835-0838	G-H	925	No plume found
10	T	0838-0842	H-G	844	No plume found
11	T	0843-0847	G-I	631	CF#13
12	T	0847-0852	I-J	631	
13	T	0852-0857	J-K	631	
14	F	0857-0911	K-L-M-N	631	
15	F	0911-0923	N-O-P	631	
16	T	0924-0928	P-Q	631	No plume found
17	Bg	0928-0940	Q-R-S	631	CF#16
18	T	0940-0948	S-T	631	
19	T	0948-0956	T-U	631	
20	F	0956-0959	U-V	631	
21	T	0959-1008	V-W	631	
NO EVENT		1008-1013			SO_2 500ppb Data lost

(Continued) EMI Flight Outline for February 13, 1981, morning flight. (Taken from Reference 39, Table 5.2)

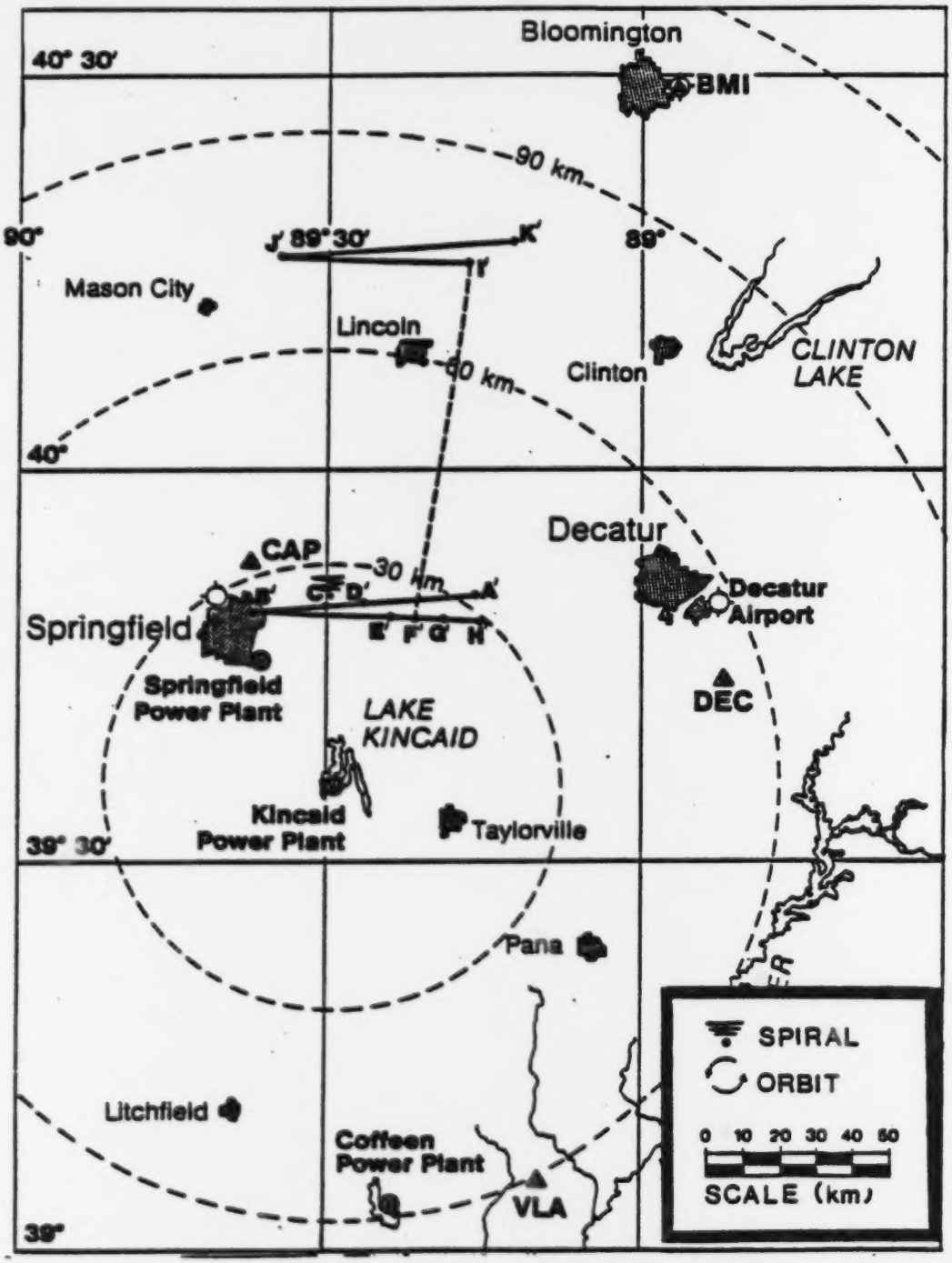
EVENT NO.	TYPE	TIME	ROUTE	ALTITUDE (m MSL)	COMMENTS; CYCLONE FILTER NO.
22	T	1013-1016	Q-X	539	
23	T	1016-1021	X-Y	539	
24	T	1022-1030	Y-Z	539	
25	F	1030-1036	Z-AA	509	CF#16
26	T	1036-1045	AA-Y	509	No plume found
27	T	1046-1056	Y-BB	539	
NO EVENT		1058-1102			SO_2 900ppb Data lost
28	F	1102-1108	CC-DD	539-600	No plume found
29	T	1108-1117	DD-BB	600	
30	T	1117-1122	BB-EE	600	
31	T	1122-1128	EE-Z	631	
32	T	1130-1135	Z-DD	661	CF#30
33	T	1137-1141	DD-Z	600	
34	T	1143-1148	Z-EE	539	
NO EVENT		1149-1154		479	Magnetic data lost Manual data show double plume: 700ppb, 100ppb SO_2
35	T	1155-1159	BB-N	448	
36	S	1159-1201		448-844	



EMI Flight Map for February 13, 1981.
(Taken from Reference 39, Figure 5.2)

EMI Flight Outline for February 13, 1981, afternoon flight. (Taken from Reference 39, Table 5.3)

EVENT NO.	TYPE	TIME	ROUTE	ALTITUDE (m MSL)	COMMENTS; CYCLONE FILTER NO.
NO EVENT		1318-1327	KSPI-A'		No data
37	T	1327-1336	A'-B'	528	
38	T	1337-1340	B'-C'	437	
39	S	1340-1343	C'	437-741	
NO EVENT		1343-1346			No data
40	T	1346-1351	D'-B'	650	No plume found
41	T	1352-1357	B'-E'	589	CF#14
42	T	1357-1404	E'-B'	528	
43	T	1406-1412	B'-F'	467	
44	T	1413-1419	F'-B'	437	
45	T	1420-1428	B'-G'	376	
46	T	1432-1439	G'-B'	406	
47	T	1440-1446	B'-F'	467	
48	T	1447-1455	F'-B'	528	Tape change; missed plume. SO_2>1000ppb CF#19
49	T	1455-1503	B'-H'	528	
50	T	1504-1512	H'-B'	589	
NO EVENT		1513-1530	B'-F'-I'		No data
51	T	1530-1536	I'-J'	528	CF#31; No USF
52	T	1538-1547	J'-K'	589	



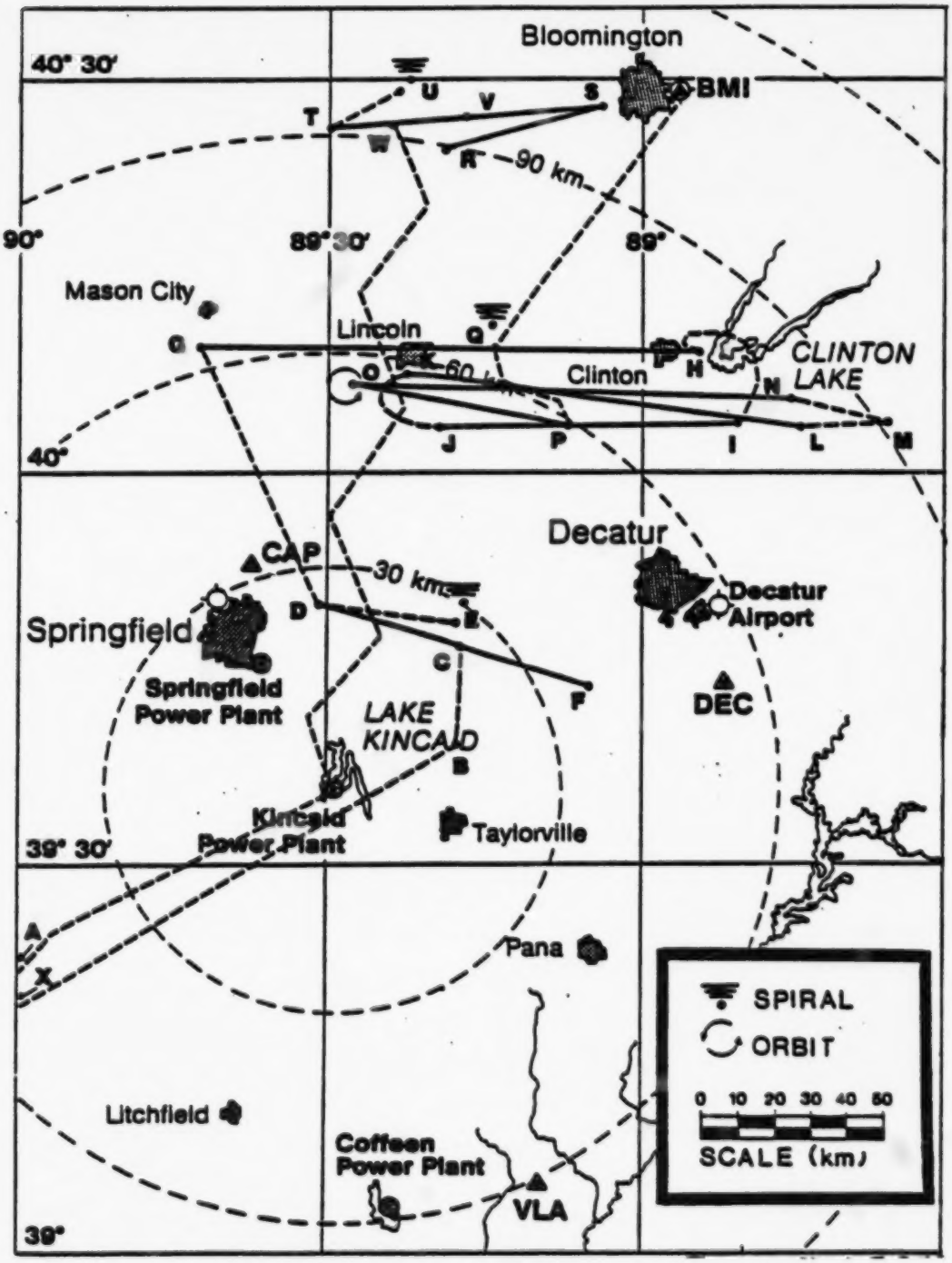
EMI Flight Map for February 13, 1981. afternoon flight. (Taken from Reference 39, Figure 5.3)

EMI Flight Outline for February 14, 1981.
(Taken from Reference 39, Table 5.4)

EVENT NO.	TYPE	TIME	ROUTE	ALTITUDE (m MSL)	COMMENTS; CYCLONE FILTER NO.
1	Bg	0746-0811	A-B	908	
2	F	0811-0814	B-C	908-542	CF#39
3	T	0814-0819	C-D	572	
4	F	0819-0824	D-E	572-390	
5	S	0826-0830	E	390-969	
NO EVENT		0830-0835		969-664	No continuous data
6	T	0835-0845	D-F	664	Altitude drop at Coffeen plume
7	T	0848-0857	F-D	572	CF#34
8	T	0857-0907	D-F	496	Coffeen again
9	T	0907-0918	F-D	511	Coffeen again; 30 sec. gap
10	F	0918-0930	D-G	511	
11	T	0930-0947	G-H	542	Probably Springfield too
12	F	0948-0955	H-I	633	
13	T	0955-1005	I-J	633	Coffeen(?) & Kincaid
14	F	1005-1010	J-K	633-450	CF#38
15	T	1010-1024	K-L	450	Coffeen(?) & Kincaid
16	F	1024-1032	L-M-N	633	
17	T	1033-1048	N-O	633	30 sec. gap
18	O	1048-1055	O	572	Some plume; not pure background.

(Continued) EMI Flight Outline for February 14, 1981. (Taken from Reference 39, Table 5.4)

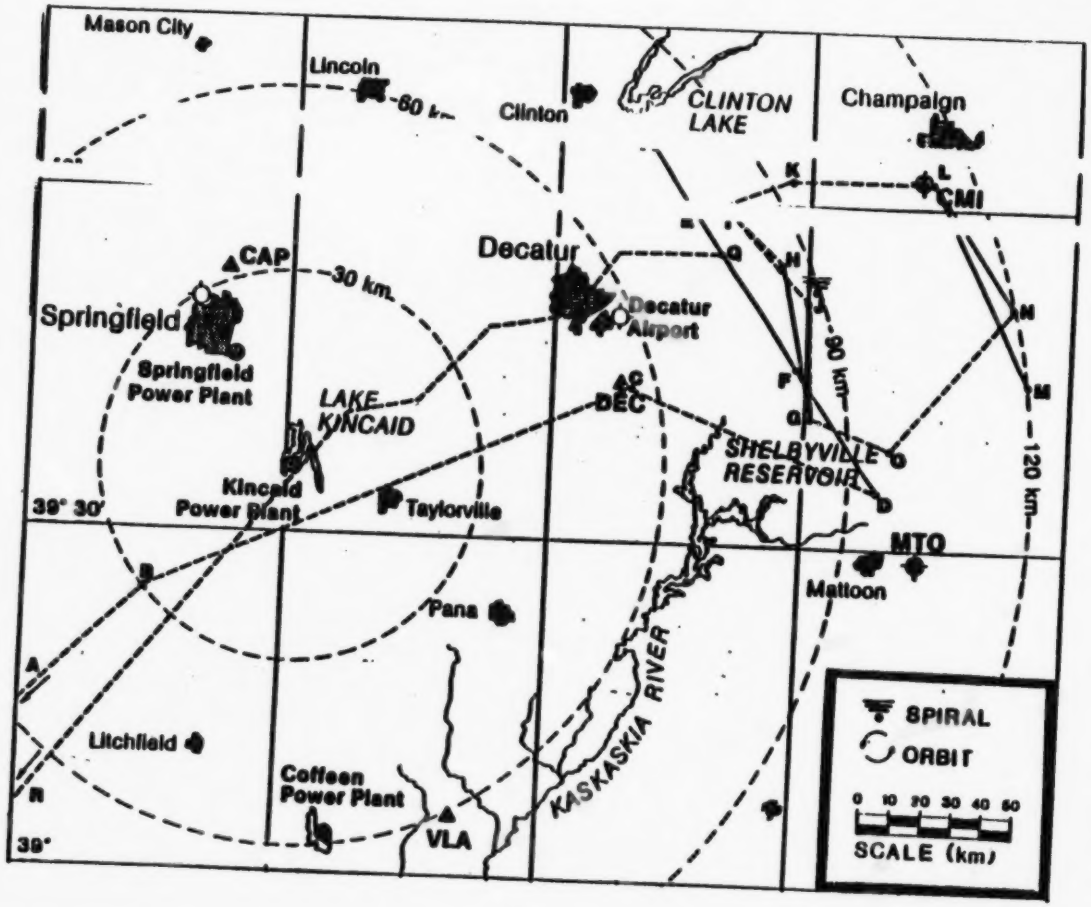
EVENT NO.	TYPE	TIME	ROUTE	ALTITUDE (m MSL)	COMMENTS; CYCLONE FILTER NO.
19	T	1055-1104	O-P	572	
20	F	1104-1109	P-Q	572-329	CF#35
21	S	1109-1112	Q	329-755	
22	F	1112-1124	Q-Blmngtn.	755-0	Diagonal crossing of Coffeen(?)
Mission II					
23	T	1312-1318	R-S	606	
24	T	1318-1328	S-T	606	
25	T	1329-1339	T-S	636	
26	T	1340-1350	S-T	667	CF#37
27	F	1351-1354	T-U	453-301	
28	S	1354-1359	U	301-941	
NO EVENT		1400-1403		941-697	
29	T	1403-1408	V-T	697	
30	T	1408-1410	T-W	636	
31	Zig-zag	1410-1454	W-Kincaid	636-545	CF#36
32	F	1454-1528	Kincaid-KSUS	606	



EMI Flight Map for February 14, 1981. (Taken from Reference 39, Figure 5.4)

EMI Flight Outline for February 16, 1981.
(Taken from Reference 39, Table 5.5)

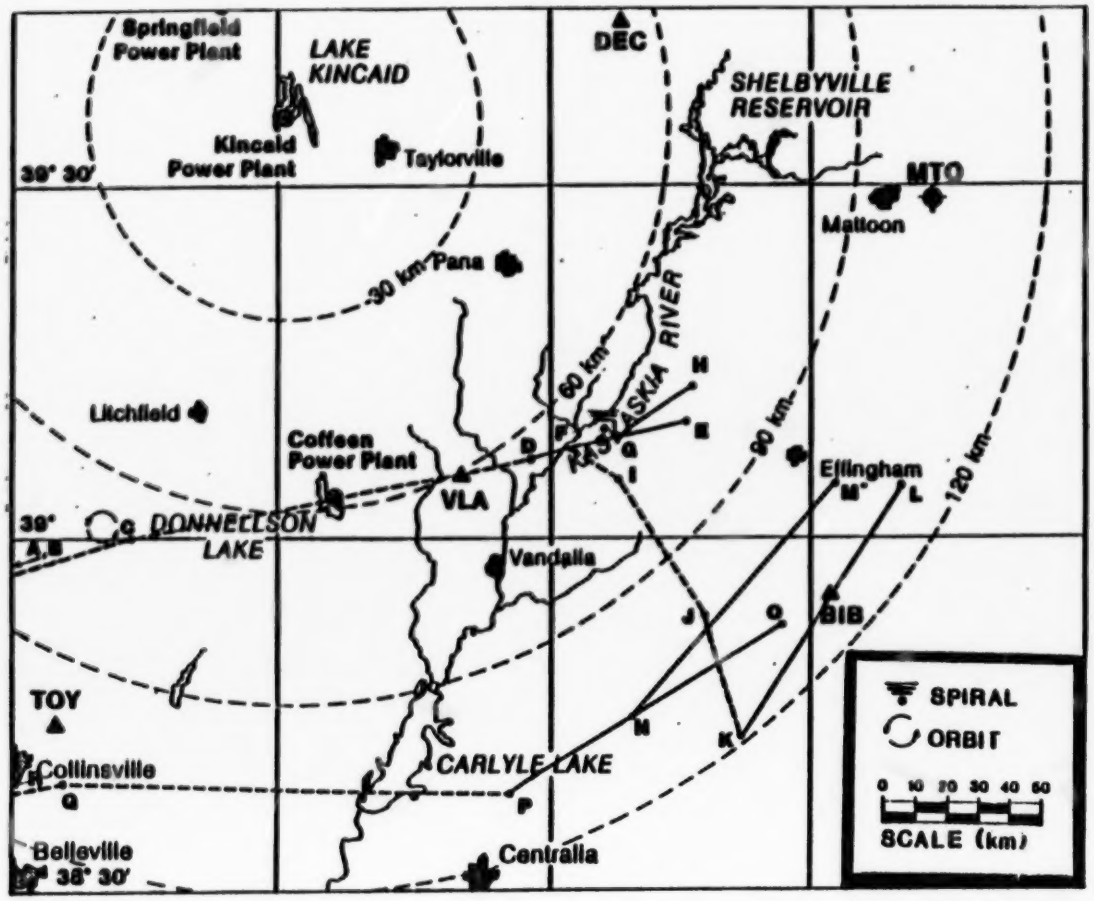
EVENT NO.	TYPE	TIME	ROUTE	ALTITUDE (m MSL)	COMMENTS; CYCLONE FILTER NO.
1	F	1310-1351	A-B-C-D	739	CF#44
2	T	1351-1407	D-E	739	
3	T	1407-1419	E-F	647	
4	T	1420-1429	F-E	678	
5	T	1431-1438	E-F	586	
6	T	1440-1447	G-H	678	Fly-by with MRI
7	F	1447-1457	H-I-J	678-342	CF#46
8	S	1458-1503	J	342-921	
9	F	1504-1512	J-G	921-769	
10	T	1512-1523	G-E	769	
11	Bg	1523-1536	E-K-L	744	
12	T	1538-1548	L-M	728	
13	T	1550-1559	M-L	708	
14	T	1559-1604	L-N	617	CF#49
15	T	1605-1611	N-L	556	30 sec. gap
16	T	1611-1616	L-N	495	
17	F	1616-1628	N-O-G	495-678	
18	T	1628-1642	G-P	678	
19	T	1643-1649	P-Q	617	CF#51
20	Zig-zag	1649-1716	Q-Kincaid	678-586	
21	F	1716-1734	Kincaid-R	769	CF47



EMI Flight Map for February 16, 1981. (Taken from Reference 39, Figure 5.5)

EMI Flight Outline for February 20, 1981.
(Taken from Reference 39, Table 5.6)

EVENT NO.	TYPE	TIME	ROUTE	ALTITUDE (m MSL)	COMMENTS; CYCLONE FILTER NO.
1	F	1035-1053	A-B-C	470-896	
2	Bg&O	1055-1101	C	622	CF#58
3	F	1101-1118	C-D	622	
4	T	1120-1124	D-E	622	
5	T	1126-1130	E-F	683	
NO EVENT		1130-1135		683-226	
6	S	1135-1140	G	287-896	
7	T	1141-1144	G-E	683	CF#53
8	T	1146-1150	E-G	683	MRI fly-by
9	T	1151-1154	G-E	531	
10	T	1154-1200	E-F	470	
11	F	1200-1215	F-I-J-K	653	1204-1209 No tape
12	T	1216-1229	K-L	592	
NO EVENT		1229-1223			
13	T	1233-1246	M-N	592	Interpret with caution; see summary text
14	T	1248-1255	N-O	653	Interpret with caution; see summary text
15	T	1257-1312	O-P	546	Interpret with caution; see summary text. CF#52
16	T	1313-1328	P-O	470	Interpret with caution; see summary text
17	T	1330-1344	O-P	592	Interpret with caution; see summary text
18	F	1345-1415	P-Q-R-KSUS	927-165	CF#57



EMI Flight Map for February 20, 1981. (Taken from Reference 39, Figure 5.6)

APPENDIX A1.2

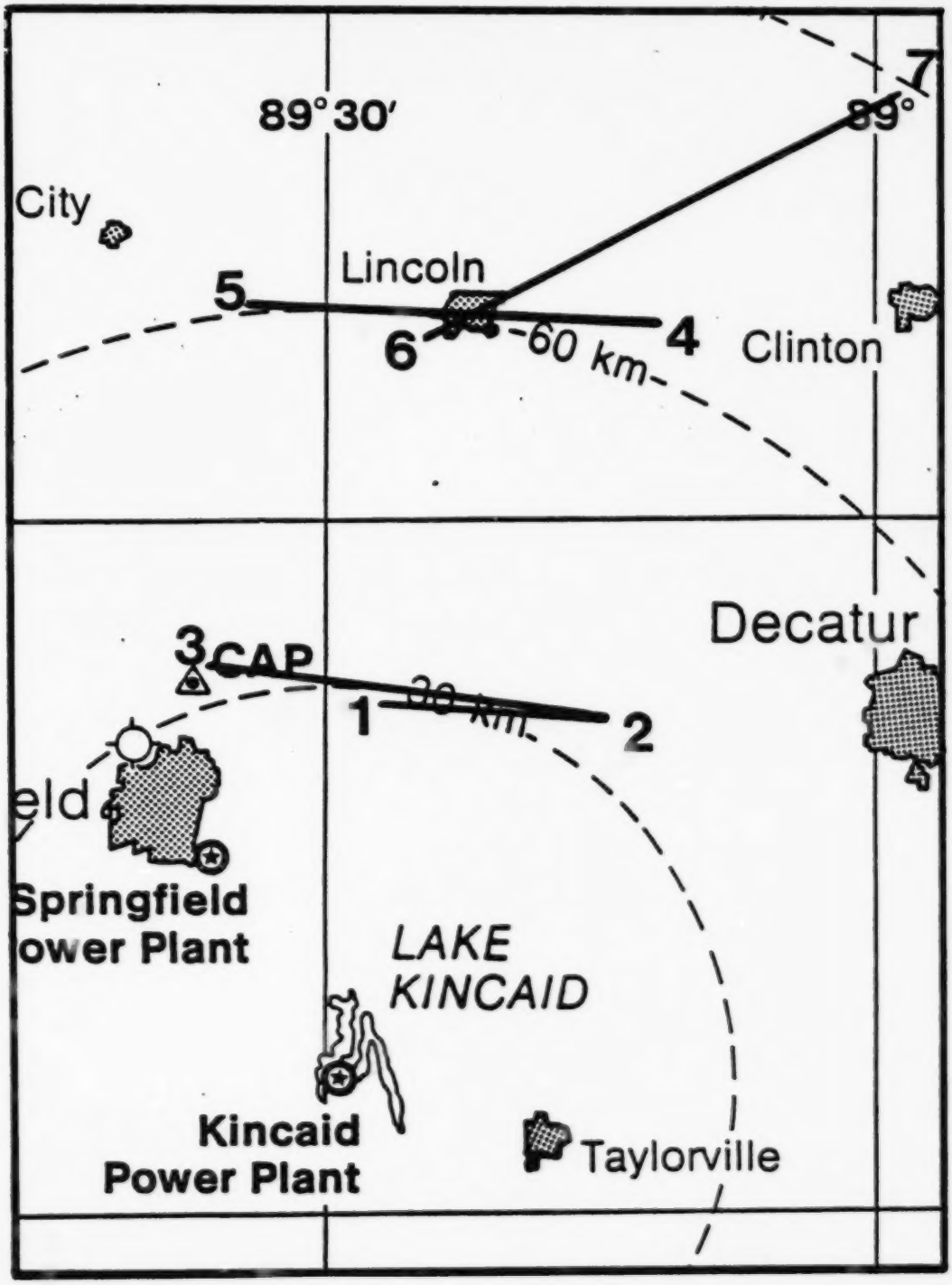
MRI AIRCRAFT FLIGHT OUTLINES AND MAPS

MRI FLIGHT OUTLINE
COLD WEATHER PLUME STUDY
Plume Chemistry at 30 km and 60 km

12 February 1981
Tape Number: 212

Pass No.	Sampling Times (MST) Start	End	Flight Type	End Points	Sampling Altitude m MSL Start	End	Traverse Length or Orbit Time	HC Bag	Impactor drum	Impactor filter 25 m	teflon 47mm red H	teflon 25mm ylw T	quartz 47mm grn Q	nylon 47mm blu N	OA 47mm blk A	Comments
1	1256	1356	Orbit	1	533		60.0 Min.	2B	A1	U3	H5	T5	Q4	N1	A22/ A23	Plume orbit 30 km
2	1356	1406	Traverse	1 - 2	533		19.2 Km.									Plume to background
3	1410	1418	Traverse	2 - 3	518		32.8 Km.				"NO FILTERS"					Plume traverse 30 km EMI cross comparison
4	1449	1502	Traverse	4 - 5	518		34.4 Km.									Plume traverse 60 km
5	1506	1606	Orbit	6	518		60.0 Min.	2W	A2	U3	H6	T6	Q4	N2	A22/ A23	Plume orbit 60 km
6	1610	1615	Spiral	6	183- 762		N.A.				"NO FILTERS"					Plume spiral
7	1616	1626	Traverse	6 - 7	518		40.0 Km.									Plume to background
8	1725	1845	Orbit	2	518		80.0 Min.	1W	A3	U4	H7	T7	Q4	N3	A22/ A23	Background some plume contamination
																Data system inop all day
										U1-2	H1-4	T1-4	Q1-3		A12/ A13	Motel blanks
													Q5		A32/ A33	Flight blanks

General weather: Clear, dry, cold; winds moderate southerly
Preflight airport temp: -4°C
Surface winds: 170° 12 m/s
Plume: North, moderate stability, well defined, limited vertical mixing, mixing to ground began 1500-1600
Observer comments: Excellent sampling conditions, good chemistry day

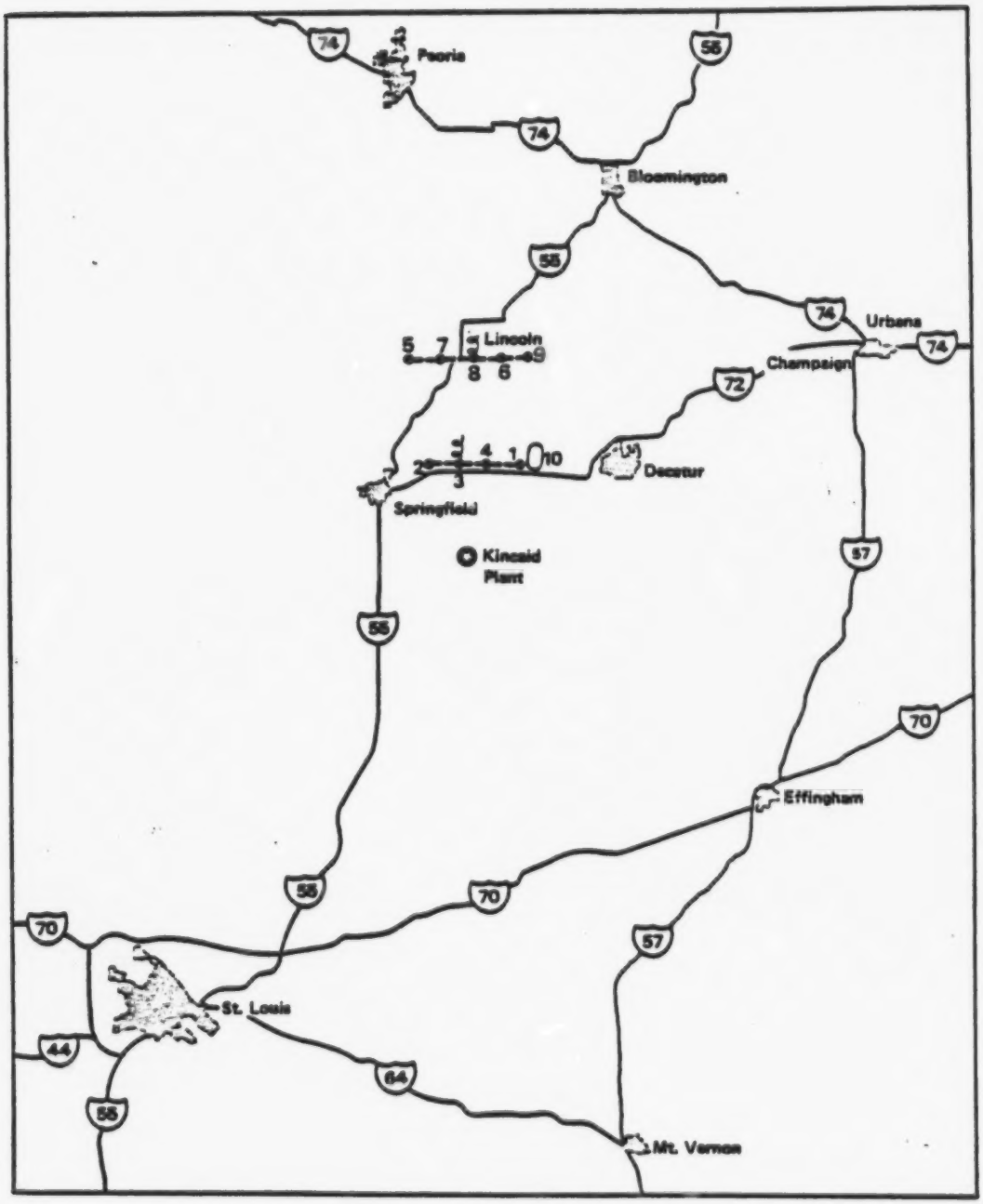


MRI Flight Map for February 12, 1981

MRI Flight Outline for February 13, 1981. (Taken from Reference 37, Table 4.30)

Pass No.	Sampling Times (MST) Start	End	Flight Type	End Points	Sampling Altitude m MSL Start	End	Traverse Length or Orbit Time	Comments
1	852	901	Traverse	2 - 1	533		26.0 Km.	Plume traverse 28 km SO_2 overrange
2	904	912	Traverse	1 - 2	488		26.0 Km.	"
3	913	921	Traverse	2 - 1	457		26.0 Km.	"
4	922	930	Traverse	1 - 2	427		26.0 Km.	Traverse below plume
5	932	940	Traverse	2 - 1	549		26.0 Km.	Traverse above plume
6	944	952	Traverse	1 - 2	518		26.0 Km.	Plume traverse 28 km SO_2 overrange
7	953	958	Traverse	2 - 4	488		15.6 Km.	Plume traverse 28 km NO_x, SO_2, b_G overrange
8	1011	1016	Spiral	3	305	- 762	N.A.	Plume spiral 28 km
9	1030	1035	Traverse	4 - 2	579		15.6 Km.	Plume traverse 28 km
10	1036	1043	Traverse	2 - 4	549		15.6 Km.	"
11	1049	1054	Traverse	2 - 4	518		15.6 Km.	Plume traverse 28 km SO_2, b_G overrange
12	1056	1100	Traverse	4 - 2	488		15.6 Km.	"
13	1102	1106	Traverse	2 - 4	457		15.6 Km.	"
14	1108	1113	Traverse	4 - 2	427		15.6 Km.	Plume traverse 28 km SO_2 overrange
15	1114	1118	Traverse	2 - 4	396		15.6 Km.	Plume traverse 28 km
16	1120	1124	Traverse	4 - 2	366		15.6 Km.	"
17	1126	1129	Spiral	3	762	- 274	N.A.	Plume spiral 28 km
18	1308	1317	Traverse	5 - 6	472		30.8 Km.	Plume traverse 57 km SO_2 overrange
19	1318	1324	Traverse	6 - 7	549		17.8 Km.	"
20	1325	1330	Traverse	7 - 6	488		17.8 Km.	Plume traverse 57 km
21	1331	1341	Traverse	6 - 5	427		30.8 Km.	Plume traverse 57 km SO_2, b_G overrange
22	1342	1350	Traverse	5 - 6	396		30.8 Km.	Plume traverse 57 km
23	1357	1400	Spiral	8	183	- 762	N.A.	Plume spiral 57 km SO_2 overrange
24	1406	1417	Traverse	5 - 9	457		35.5 Km.	Plume traverse 57 km SO_2, b_G overrange
25	1431	1531	Orbit	10	457		60.0 Min.	Background orbit with plume interference

General weather: Clear, dry winds southerly-light AM, moderate PM
Pre-flight airport temperature: 9°C
Surface winds: 130° 3 m/s
Plume: North, vertically stable throughout day, light early morning winds caused some plume meandering earlier in day
Observer comments:

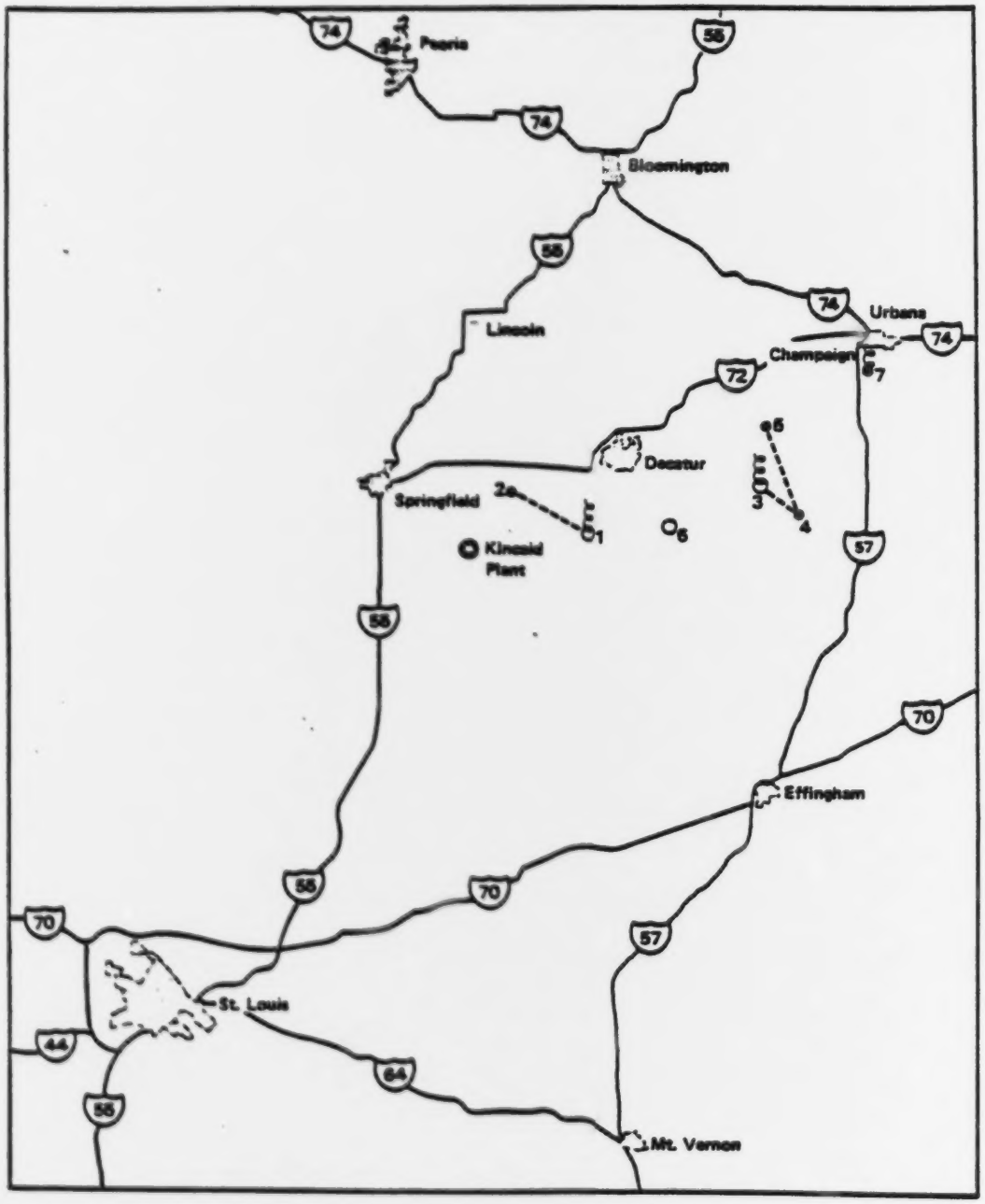


MRI Flight Map for February 13, 1981.
(Taken from Reference 37, Table 4.6)

MRI Flight Outline for February 16, 1981. (Taken from Reference 37, Table 4.13)

Pass No.	Sampling Times (MST) Start	End	Flight Type	End Points	Sampling Altitude m MSL Start	End	Traverse Length or Orbit Time	Comments
1	1200	1300	Orbit	1	488		60.0 Min.	Plume orbit 36 km some sampling in clouds
2	1300	1307	Traverse	1 - 2	640		22.4 Km.	Plume to background
3	1328	1428	Orbit	3	610		60.0 Min.	Plume orbit 81 km
4	1428	1433	Traverse	3 - 4	610		18.0 Km.	Plume to background
5	1441	1447	Traverse	4 - 5	671		22.4 Km.	Plume traverse 88 km EMI cross comparison
6	1452	1457	Spiral	3	198 -	914	N.A.	Plume spiral 81 km
7	1503	1507	Zero Spiral		914 -	244	N.A.	Zero spiral Champaign airport
8	1719	1819	Orbit	6	762		60.0 Min.	Background orbit exceptionally hazy

General weather: Overcast, warm, humid; fog and low level clouds in sampling area, some sampling done in clouds; winds moderate WSW; background very hazy, visibility low
Preflight airport temperature: 15°C
Surface winds: 240° 14 m/s
Plume: ENE, stable, well defined, no vertical mixing
Observer comments: Should be an interesting plume chemistry day

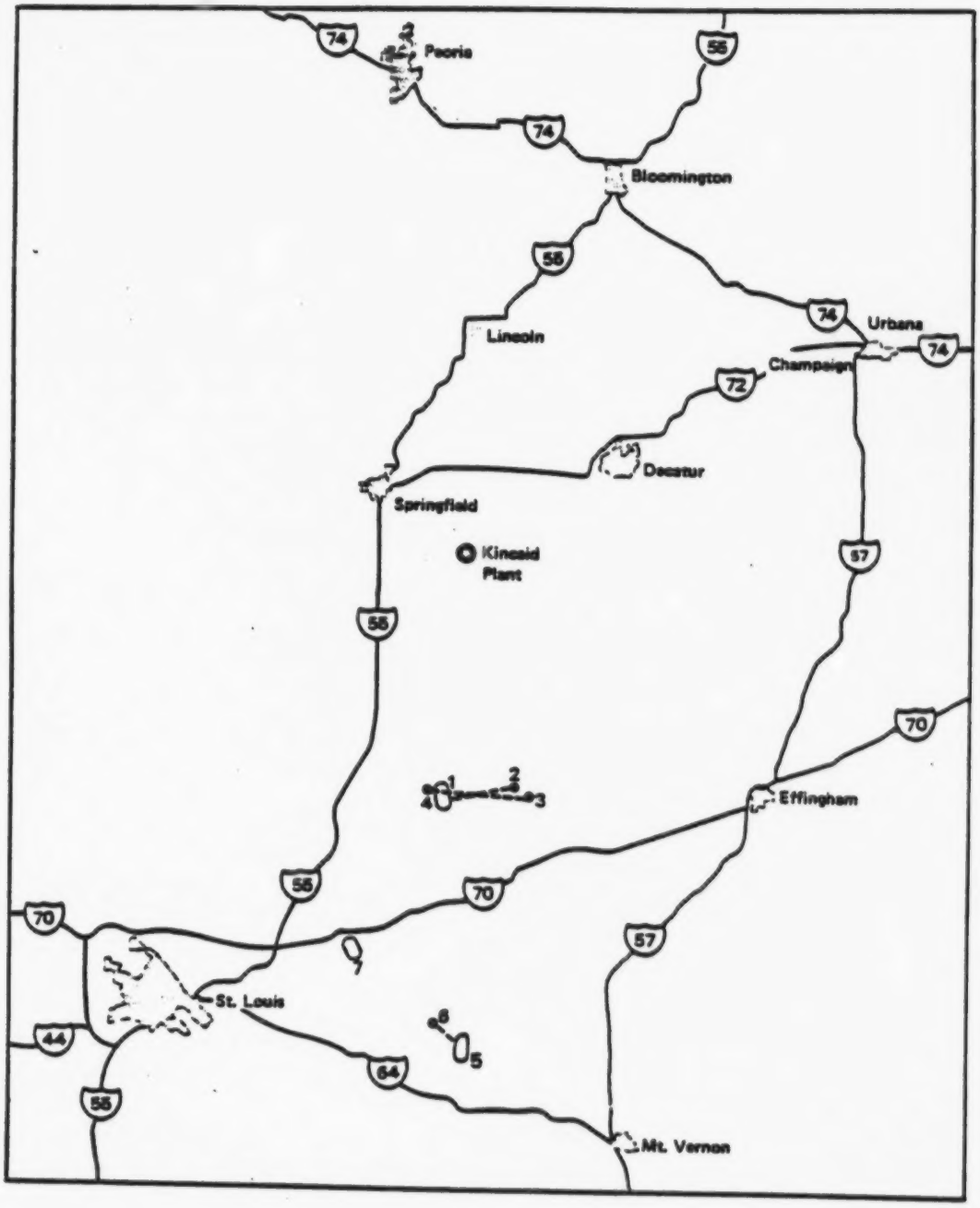


MRI Flight Map for February 16, 1981.
(Taken from Reference 37, Figure 4.2)

MRI Flight Outline for February 20, 1981, first flight. (Taken from Reference 37, Table 4.19)

Pass No.	Sampling Times (MST) Start	End	Flight Type	End Points	Sampling Altitude m MSL Start	End	Traverse Length or Orbit Time	Comments
1	320	420	Orbit	1	518		60.0 Min.	Plume orbit 58 km SO_2 overrange
2	421	426	Traverse	1 - 2	518		17.0 Km.	Plume to background
3	445	453	Traverse	3 - 4	518		28.2 Km.	Plume traverse 58 km
4	515	615	Orbit	5	518		60.0 Min.	Plume orbit 120 km
5	615	619	Traverse	5 - 6	518		11.2 Km.	Plume to background
6	619	716	Orbit	7	518		56.9 Min.	Background orbit with plume interference

General weather: Clear, dry, strong northwest wind
Preflight airport temperature: 7°C
Surface winds: 320° 16 m/
Plume: Southeast, stable, very narrow, no mixing
Observer comments: Plume 400 ft thick from top to bottom, very difficut to stay in the plume



MRI Flight Map for February 20, 1981, first flight. (Taken from Reference 37, Figure 4.3)

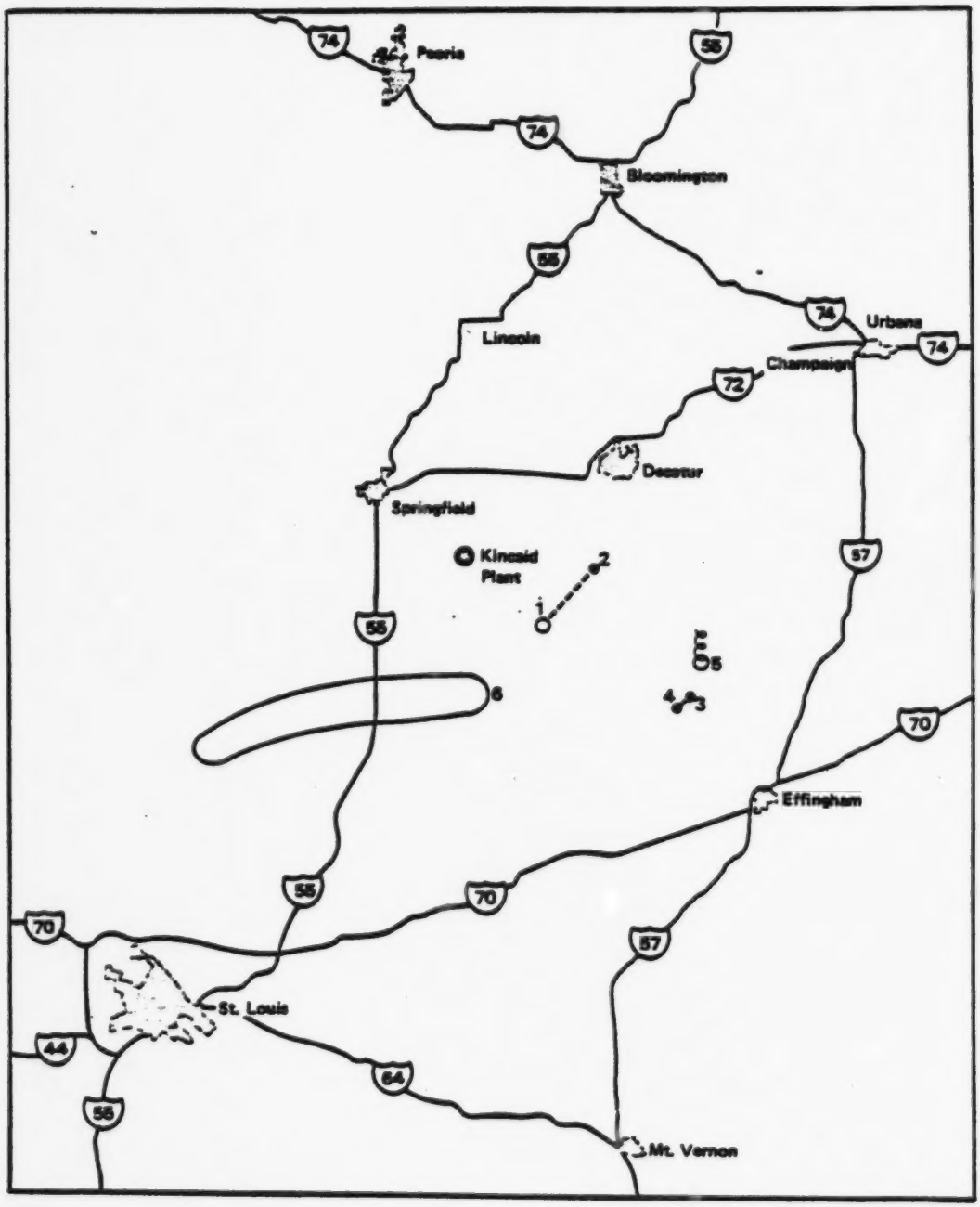
MRI Flight Outline for February 20, 1981, second flight. (Taken from Reference 37, Table 4.24)

Pass No.	Sampling Times (MST) Start	End	Flight Type	End Points	Sampling Altitude m MSL Start	End	Traverse Length or Orbit Time	Comments
1	1014	1114	Orbit	1	488		60.1 min.	Plume orbit 32 km SO_2 overrange
2	1114	1121	Traverse	1 - 2	488		22.1 km	Plume to background 32 km
3	1148	1150	Traverse	3 - 4	671		7.5 km.	Plume traverse 76 km
4	1153	1253	Orbit	5	610		60.0 min.	Plume orbit 76 km
5	1300	1304	Spiral	5	1067	- 183	N.A.	Plume spiral
6	1309	1409	Orbit	6	610		60.0 min.	Background orbit

General weather: Clear, dry, warmer than earlier flight: light to moderate winds west northwest.

Plume: Southeast, wind direction changing during sampling, stable, no vertical mixing, some meandering.

Observer comments: Best EMI cross comparison in program, plume easier to stay with than earlier in the day.



MRI Flight Map for February 20, 1981, second flight. (Taken from Reference 37, Figure 4.4)

APPENDIX A2

GDDB FILES, THEIR CONTENTS AND FORMATS

APPENDIX A2.1

Listing of Files in GDDB-CWPS

GDDB-CWPS: FILES ON TAPE 1

SUMARY.212		LIST OF FILES FOR 2/12/81	
EMIA81.212	EMI	EMI AIRCRAFT CONTINUOUS DATA	STATE-20
MRIA81.212	MRI	MRI AIRCRAFT CONTINUOUS DATA	STATE-20
M81INT.212	MRI	AIRCRAFT INTEGRATED SAMPLE DATA	STATE-20
M81PIX.212	MRI	PIXE ELEMENTAL ANALYSIS DATA	STATE-20
M81XRF.212	MRI	XRF ELEMENTAL ANALYSIS DATA	STATE-20
AV81AS.212	AV	AIRSONDE DATA	STATE-VS
AV81PI.212	AV	PIBAL DATA	STATE-VS
R81VS.212	ROCKWELL	SUPPLEMENTAL TSOND DATA	STATE-VS
R81MET.212	ROCKWELL	MET DATA AT KINKAID	STATE-20
R81NWS.212	ROCKWELL	NWS SURFACE STATION DATA	STATE-20
R81STK.212	ROCKWELL	STACK SAMPLING DATA	STATE-20
ISWS81.RAD	ISWS	TOTAL SOLAR RADIATION DATA	STATE-20

SUMARY.213		LIST OF FILES FOR 2/13/81	
EMIA81.213	EMI	EMI AIRCRAFT CONTINUOUS DATA	STATE-20
MRIA81.213	MRI	MRI AIRCRAFT CONTINUOUS DATA	STATE-20
M81INT.213	MRI	AIRCRAFT INTEGRATED SAMPLE DATA	STATE-20
M81PIX.213	MRI	PIXE ELEMENTAL ANALYSIS DATA	STATE-20
M81XRF.213	MRI	XRF ELEMENTAL ANALYSIS DATA	STATE-20
AV81AS.213	AV	AIRSONDE DATA	STATE-VS
AV81PI.213	AV	PIBAL DATA	STATE-VS
R81VS.213	ROCKWELL	SUPPLEMENTAL TSOND DATA	STATE-VS
R81MET.213	ROCKWELL	MET DATA AT KINKAID	STATE-20
R81NWS.213	ROCKWELL	NWS SURFACE STATION DATA	STATE-20
R81STK.213	ROCKWELL	STACK SAMPLING DATA	STATE-20
ISWS81.RAD	ISWS	TOTAL SOLAR RADIATION DATA	STATE-20

SUMARY.214		LIST OF FILES FOR 2/14/81	
EMIA81.213	EMI	EMI AIRCRAFT CONTINUOUS DATA	STATE-20
AV81AS.214	AV	AIRSONDE DATA	STATE-VS
AV81PI.214	AV	PIBAL DATA	STATE-VS
R81VS.214	ROCKWELL	SUPPLEMENTAL TSOND DATA	STATE-VS
R81MET.214	ROCKWELL	MET DATA AT KINKAID	STATE-20
R81NWS.214	ROCKWELL	NWS SURFACE STATION DATA	STATE-20
R81STK.214	ROCKWELL	STACK SAMPLING DATA	STATE-20
ISWS81.RAD	ISWS	TOTAL SOLAR RADIATION DATA	STATE-20

GDDB-CWPS: FILES ON TAPE 2

SUMARY.216		LIST OF FILES FOR 2/16/81	
EMIA81.216	EMI	EMI AIRCRAFT CONTINUOUS DATA	STATE-20
MRIA81.216	MRI	MRI AIRCRAFT CONTINUOUS DATA	STATE-20
M81INT.216	MRI	AIRCRAFT INTEGRATED SAMPLE DATA	STATE-20
M81PIX.216	MRI	PIXE ELEMENTAL ANALYSIS DATA	STATE-20
M81XRF.216	MRI	XRF ELEMENTAL ANALYSIS DATA	STATE-20
AV81AS.216	AV	AIRSONDE DATA	STATE-VS
AV81PI.216	AV	PIBAL DATA	STATE-VS
R81VS.216	ROCKWELL	SUPPLEMENTAL TSOND DATA	STATE-VS
R81MET.216	ROCKWELL	MET DATA AT KINKAID	STATE-20
R81NWS.216	ROCKWELL	NWS SURFACE STATION DATA	STATE-20
R81STK.216	ROCKWELL	STACK SAMPLING DATA	STATE-20
ISWS81.RAD	ISWS	TOTAL SOLAR RADIATION DATA	STATE-20

SUMARY.220		LIST OF FILES FOR 2/20/81	
EMIA81.220	EMI	EMI AIRCRAFT CONTINUOUS DATA	STATE-20
MRIA81.220	MRI	MRI AIRCRAFT CONTINUOUS DATA	STATE-20
MRIA81B.220	MRI	MRI AIRCRAFT CONTINUOUS DATA	STATE-20
M81INT.220	MRI	AIRCRAFT INTEGRATED SAMPLE DATA	STATE-20
M81PIX.220	MRI	PIXE ELEMENTAL ANALYSIS DATA	STATE-20
M81XRF.220	MRI	XRF ELEMENTAL ANALYSIS DATA	STATE-20
AV81AS.220	AV	AIRSONDE DATA	STATE-VS
AV81PI.220	AV	PIBAL DATA	STATE-VS
R81VS.220	ROCKWELL	SUPPLEMENTAL TSOND DATA	STATE-VS
R81MET.220	ROCKWELL	MET DATA AT KINKAID	STATE-20
R81NWS.220	ROCKWELL	NWS SURFACE STATION DATA	STATE-20
R81STK.220	ROCKWELL	STACK SAMPLING DATA	STATE-20
ISWS81.RAD	ISWS	TOTAL SOLAR RADIATION DATA	STATE-20

APPENDIX A2.2

Partial Listing of Contents of Data Files of 2/13/81

18 RECORDS AT BEGINNING OF FILE

```
20   3  22  EMIA81.213  02/13/81      2. SECONDS
COLD WEATHER PLUME STUDY 1981 EMI        EMI AIRCRAFT CONTINUOUS DATA
(8F10.2,/,8F10.2,/,1F10.2,1F10.0,2F10.2,2F10.3,20X)
DATE       TIME CST  ALTITUDE  @SO2       VOR        VORFQ      DME        TEMP
TDP        SO2       NO        NOX        OZONE      BSCAT      ANC        CHARGE
PRESSURE   EVENT     @NOX      @O3        LATITUDE   LONGITUD
YYMMDD     HHMMSS    M MSL     PPB        DEGREES    HZ         KM         DEGREE C
DEGREE C   PPB       PPB       PPB        PPB        10-4M-1    KN/CC      SEE (5)
MILLIBAR   CODE      PPB       PPB        DD.D  N    DD.D  W
     10857
     81.02 240000.00   3000.00   1000.00    360.00    118.00    250.00     25.00
     25.00   2000.00   1000.00   1000.00    100.00     10.00    100.00  12000.00
   1100.00       10.   1000.00    200.00    40.500    91.000
      0.00      0.00      0.00      0.00      0.00    100.00      0.00    -25.00
    -25.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
    500.00        0.      0.00      0.00    38.000    87.000
 810213.00  74632.00    904.95    100.00     51.00    117.40     95.19      0.80
 -10000.00     -2.04     14.24     19.64  -9959.69      0.21      3.54      4.00
```

35 RECORDS AT END OF FILE

```
    982.20        0.    500.00    200.00    40.303    88.999
 810213.00 154916.00    467.14    500.00    123.00    115.20    545.04     -1.45
 -10002.09     40.98     -0.89     16.63     23.74      0.45     20.09     51.63
    982.20        0.    500.00    200.00    40.302    88.998
 810213.00 154918.00    467.14    500.00    116.00    115.20     79.27     -1.40
 -10002.52     40.16      1.12     18.07     38.75      0.47     20.05     51.00
    982.20        0.    500.00    200.00    40.301    88.997
COMMENTS:
```

1) @SO2,@NOX,@O3, AND @ANC CONTAIN VALUES OF SO2, NO/NOX,O3, AND ANC INSTRUMENT RANGE SETTINGS. THE RANGE INFORMATION HAS BEEN INCORPORATED INTO THE DATA VALUES OF THE APPROPRIATE POLLUTANT CHANNELS.

2) VOR/DME DATA LOGGING WAS BASED ON CONTINUOUS CYCLING (APPROXIMATELY EVERY FIVE SECONDS) BETWEEN TWO GROUND VORTAC STATIONS. THE VORTAC FREQUENCIES ARE RECORDED IN THE VORFQ CHANNEL.

3) LONG/LAT DATA ARE INFERRED BASED ON THE VOR/DME DATA.

4) ANC = AITKEN NUCLEI COUNT. KN/CC = 1000 NUCLEI PER CUBIC CENTIMETER.

5) CHARGE = UNCALIBRATED VOLTAGE SIGNAL OF THE WASHINGTON UNIVERSITY AEROSOL CHARGER.

6) THE EMI AIRCRAFT ALSO MADE CONTINUOUS MEASUREMENT OF THE PARTICULATE SULFUR AND THE H2SO4 COMPONENT OF IT. IT IS CURRENTLY BELIEVED THAT THE DATA OF THESE PARAMETERS ARE NOT USABLE, AND ARE NOT INCLUDED HERE. ATTEMPTS WILL CONTINUE TO BE MADE TO VERIFY THIS. IF GOOD DATA IS REALIZED, IT WILL BE MADE AVAILABLE LATER.

7) THE EMI AIRCRAFT ALSO MADE SOME AEROSOL SIZE DISTRIBUTION MEASUREMENTS BASED ON AN OPTICAL PARTICLE COUNTER AND AN ELECTRICAL AEROSOL ANALYZER. THESE DATA HAVE NOT YET BEEN PROCESSED, AND THE RAW DATA ARE NOT INCLUDED HERE. RESULTS OF THE INFERRED AEROSOL SIZE DISTRIBUTIONS WILL BE MADE AVAILABLE IN HARD COPY FORM IN THE NEAR FUTURE.

25 RECORDS AT BEGINNING OF FILE

```
20   4  30  MRIA81.213   2/13/81    10. SECONDS
COLD WEATHER PLUME STUDY 1981 MRI        MRI AIRCRAFT CONTINUOUS DATA
(8F10.2,/,6F10.1,F10.3,F10.0,/,8F10.3,/,6F10.2)
TIME CST  ALTITUDE  PRESSURE  IAS       TURB      TEMP      TDP       CNC
CHARGER   LOGBSPGR  O3        NT        NOX       SO2       DISTANCE  BAG FLAG
ALPHAB-G  ALPHAG-R  BSPGREEN  BSP BLUE  BSP RED   NO        NEPHTEMP  UVRAD
TOTRAD    EAA CURR  EVENT     RH-CALC   LATITUDE  LONGITUD
HHMMSS    M MSL     MB        M/SEC     R UNIT    DEG C     DEG C     1000CM-3
                    PPB       PPB       PPB       PPB       KM        V
                    10-4/M    10-4/M    10-4/M    PPB       DEG K     W/M2
W/M2      NAMP      CODE      PERCENT   DEGREES   DEGREES
     13264
 240000.00   3000.00   1010.00     71.00      7.00     14.00      7.60    111.00
     385.0     416.0     500.0    1500.0    1500.0    1511.0    80.000        5.
     5.780     5.780    14.450    18.890     9.594  1518.000   300.000    37.740
   1624.00   4930.00      5.00    100.00     41.00     90.00
      0.00      0.00      0.00      0.00      0.00    -10.10    -27.70      0.00
    -38.0       0.0      -4.0      -2.0       0.0     -11.0     0.000        0.
   -1.670    -1.860     0.000     0.000     0.000    -7.000     0.000    -0.410
      0.00   -642.00      0.00      0.00     38.00     88.00
  85229.00    523.00    971.00     52.00      0.30      0.00    -13.10      2.00
    -15.0     238.0      39.0      11.0       6.0       6.0     0.050        0.
    1.680     1.700     0.240     0.330     0.162     6.000   277.000    15.110
   467.00   -999.00      2.00     37.01      0.00      0.00
  85230.00    523.00    971.00     52.00      0.30      0.00    -13.10      2.00


 30 RECORDS AT END OF FILE

      35.0     253.0      35.0      16.0      19.0      -1.0    59.980        0.
    1.540     1.870     0.339     0.454     0.220     8.000   276.000    15.180
   412.00      3.00   -999.00     35.83      0.00      0.00
 153115.00    468.00    968.00     56.00      0.40     -0.90   -999.00     13.00
      34.0     252.0      35.0      17.0      19.0      -1.0    60.000        0.
    1.570     1.790     0.331     0.446     0.219     9.000   276.000    15.040
   402.00      3.00   -999.00-100000.00      0.00      0.00
 153115.00      0.00      0.00      0.00      0.00      0.00      0.00      0.00
       0.0       0.0       0.0       0.0       0.0       0.0     0.000        0.
     0.000     0.000     0.000     0.000     0.000     0.000     0.000     0.000
      0.00      0.00      0.00    100.00      0.00      0.00
COLD WEATHER PLUME STUDY, KINCAID GENERATING STATION, MRI AIRBORNE SAMPLING
DATA, COLLECTED FROM 02/12/81 THRU 01/20/81.
```

1) LOCATION DATA ARE BASED ON INTERPOLATED LONGITUDE AND LATITUDE VALUES BETWEEN EVENT END POINT VALUES. END POINT VALUES ARE INFERRED FROM AIRCRAFT NAVIGATIONAL DATA.

2) R UNIT = CM^(2/3)/SEC

3) NT REPRESENTS AL GASEOUS NITROGEN OXIDES, INCLUDING HNO3.
   NOX = NT-HNO3

4) RH-CALC REPRESENTS CALCULATED RELATIVE HUMIDITY BASED ON TEMPERATURE (T) AND DEW-POINT (TDP) DATA ACCORDING TO FORMULA:
   RH-CALC = ((231.8 + 1.8(TDP - 0.1T)) / (231.8 + 1.62T))**8

5) TIME IS CENTRAL STANDARD TIME (CST).

6) VALUE OF +/- 999 FOR ANY CHANNEL INDICATES NO VALID DATA.

```
25 RECORDS AT BEGINNING OF FILE

20   4  26  M81INT.213   2/13/80     0. IREGULAR
CWPS 1981                    MRI       AIRCRAFT INTEGRATED SAMPLE DATA
(2F10.0,6F10.3,/,8F10.3,/,8F10.3,/,2F10.3,60X)
TSTART     TEND       NO3P       SO4P       NH4P       SP         TNO3IO     TNO3P
PAN        ETHANE     ETHYLENE   ACETYLEN   PROPANE    PROPENE    I-BUTANE   N-BUTANE
I-PENTAN   N-PENTAN   2-METHP    3-METHP    N-HEXANE   BENZENE    TOLUENE    ETHYLBZ
M+P-XYL    O-XYLENE
HHMMSS     HHMMSS     UG/M3      UG/M3      UG/M3      UG/M3      UG/M3      UG/M3
PPB        PPBC       PPBC       PPBC       PPBC       PPBC       PPBC       PPBC
PPBC       PPBC       PPBC       PPBC       PPBC       PPBC       PPBC       PPBC
PPBC       PPBC
         4
  236000.    236000.      0.830      7.520      1.210      1.870      2.840      2.790
    0.100      8.000     11.700      6.200      7.400      0.600      2.000      5.000
    3.900      2.100      1.700      1.700      1.200      3.300      6.600      1.100
    3.500      1.700
       0.         0.     -0.180      2.830      0.860      1.230      0.920      0.670
    0.100      6.900      9.800      5.200      6.600      0.100      1.400      4.600
    3.500      1.700      0.600      1.100      0.600      2.600      4.200      0.700
    2.200      1.100
   85200.    102000.      0.480      2.830      0.930      1.230      1.160      0.980
    0.100      8.000     11.700      6.200      7.400      0.100      2.000      5.000
    3.900      2.100      1.700      1.700      0.600      3.300      4.200      0.700
    2.200      1.100
  103000.    113000.      0.830      3.500      0.860      1.410      0.920      0.860

30 RECORDS AT END OF FILE

 -995.000   -995.000
  131000.    142000.      0.770      7.520      1.210      1.870      1.310      0.670
    0.100      6.900      9.800      5.200      6.600      0.600      1.400      4.600
    3.500      1.700      0.600      1.100      1.200      2.600      6.600      1.100
    3.500      1.700
  143000.    153000.     -0.180      4.540      0.890      1.870      2.840      2.790
 -995.000   -995.000   -995.000   -995.000   -995.000   -995.000   -995.000   -995.000
 -995.000   -995.000   -995.000   -995.000   -995.000   -995.000   -995.000   -995.000
 -995.000   -995.000
TSTART,TEND = START/END TIMES (CST) OF INTEGRATED SAMPLE
THE AEROSOL CONCETRATION DATA (CHANNELS 3-8) ARE BASED ON ANALYSES OF
INTEGRATED FILTER SAMPLES.
THE PAN AND HYDROCARBON DATA (CHANNELS 9-26) ARE BASED ON ANALYSES OF
INTEGRATED BAG SAMPLES.
THE FOLLOWING ARE DEFINITIONS OF PARAMETERS WHOSE NAMES MAY NOT BE
SELF-EXPLANATORY:
NO3P     = PARTICULATE NITRATE < 2.5 MICRONS
SO4P     = PARTICULATE SULFATE < 2.5 MICRONS
NH4P     = PARTICULATE AMMONIUM < 2.5 MICRONS
SP       = PARTICULATE SULFUR < 2.5 MICRONS
TNO3IO   = TOTAL INORGANIC NITRATE
TNO3P    = TOTAL PARTICULATE NITRATE
ACETYLEN = ACETYLENE
I-PENTAN = I-PENTANE
N-PENTAN = N-PENTANE
2-METHP  = 2-METHYLPENTANE
3-METHP  = 3-METHYLPENTANE
ETHYLBZ  = ETHYLBENZENE
M+P-XYL  = M+P-XYLENE
```

35 RECORDS AT BEGINNING OF FILE

```
20   9  67  M81PIX.213   2/13/81      0. IREGULAR
CWPS 1981                   MRI         PIXE ELEMENTAL ANALYSIS DATA
(8F10.2)
TSTART    TEND      NA1       NA2       NA3       NA4       NAF       AL1
AL2       AL3       AL4       ALF       SI1       SI2       SI3       SI4
SIF       P 1       P 2       P 3       P 4       P F       S 1       S 2
S 3       S 4       S F       CL1       CL2       CL3       CL4       CLF
K 1       K 2       K 3       K 4       K F       CA1       CA2       CA3
CA4       CAF       TI1       TI2       TI3       TI4       TIF       MN1
MN2       MN3       MN4       MNF       FE1       FE2       FE3       FE4
FEF       CU1       CU2       CU3       CU4       CUF       ZN1       ZN2
ZN3       ZN4       ZNF
HHMMSS    HHMMSS    UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3
UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3
UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3
UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3
UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3
UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3
UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3
UG/M3     UG/M3     UG/M3
        2
236000.00 236000.00     85.00     92.50     27.70      7.20      0.00    621.00
    80.20     23.40      1.40      0.00   1900.00    317.00     96.60     23.80
   195.00    -12.60     -7.10    -15.00    -13.70    -30.20    217.00     48.20
    33.10    219.00   1240.00     87.30     17.70      0.00      0.00      0.00
   262.00     54.00     14.90      5.10     58.90    570.00     78.50     20.90
     5.20      0.00     62.80     12.00      3.30      1.50      0.00      6.10
    -0.70      3.10      8.60     29.00   1220.00    194.00     48.40     14.50
     6.20      3.40      0.80      0.00      0.00      0.00     11.50     10.40
     4.50      3.20      0.00
     0.00      0.00     68.10     -6.80     35.60     -4.30      0.00    182.00
    94.80     27.10     -4.60      0.00    500.00    360.00     61.40     -0.60
   -35.40    -12.60     -7.10    -15.00    -13.70    -30.20     23.50     16.50
    17.30     19.60   1650.00     25.60     61.50      0.00      0.00      0.00
```

18 RECORDS AT END OF FILE

```
     4.50      3.20      0.00
143000.00 153000.00     68.10     92.50     35.60     -4.30      0.00    182.00
    94.80     27.10     -4.60      0.00    500.00    360.00     61.40     -0.60
   195.00    -12.60     -7.10    -15.00    -13.70    -30.20     23.50     16.50
    17.30     19.60   1650.00     25.60     61.50      0.00      0.00      0.00
    48.90     69.90      8.80     -1.90     58.90    118.00     84.80     15.00
     1.40      0.00     12.50      7.20      2.20     -0.10      0.00      3.60
    -0.70      3.10     -0.20     29.00     93.70     95.30     20.20      3.90
    34.60      0.00      0.00      0.00      0.00      0.00     23.00     35.60
    26.60      9.20      0.00
```

THE DATA IN THIS FILE ARE BASED ON IMPACTOR SAMPLES COLLECTED IN THE MRI AIRCRAFT.

ELEMENTAL IMPACTOR DATA OF THE FOUR STAGES REPRESENT 50% CUTS AT 4,2,1,0.5 MICRONS.

SAMPLE COLLECTION WAS ON 2 MICRON TEFLON AFTER FILTER, AND ANALYSIS WAS BY PIXE.

```
20 RECORDS AT BEGINNING OF FILE

20   5  34  M81XRF.213   2/13/81      0. IREGULAR
CWPS 1981                     MRI        XRF ELEMENTAL ANALYSIS
(2F10.0,6F10.3,/,8F10.3,/,8F10.3,/,8F10.3,/,2F10.3,60X)
TSTART    TEND      AL        SI        P         S         CL        K
CA        TI        V         CR        MN        FE        NI        CU
ZN        GA        AS        SE        BR        RB        SR        Y
ZR        PD        AG        CD        IN        SN        SB        BA
HG        PB
HHMMSS    HHMMSS    UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3
UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3
UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3
UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3     UG/M3
UG/M3     UG/M3
        3
  236000.   236000.     0.237     0.212     0.073     1.870    -0.005     0.057
    0.024     0.007     0.002     0.001     0.001     0.065     0.002    -0.001
    0.015     0.002     0.007     0.004     0.003     0.003     0.001     0.000
    0.013     0.008     0.002     0.019     0.001     0.012    -0.007     0.022
    0.000     0.011
       0.        0.     0.144     0.200     0.048     1.240    -0.009     0.033

15 RECORDS AT END OF FILE

    0.013     0.006     0.002     0.019    -0.003     0.010    -0.011    -0.043
    0.000     0.007
  103000.   113000.     0.157     0.206     0.070     1.410    -0.009     0.057
    0.021     0.007     0.002     0.000     0.000     0.065     0.002    -0.002
    0.012     0.002     0.007     0.003     0.003     0.000    -0.001     0.000
   -0.008     0.008    -0.003     0.011    -0.004     0.012    -0.010     0.022
    0.000     0.004
  131000.   153000.     0.237     0.212     0.073     1.870    -0.005     0.033
    0.021     0.006     0.002     0.000     0.001     0.041     0.001    -0.001
    0.013     0.001     0.001     0.004     0.002     0.003     0.001     0.000
    0.002     0.003    -0.001     0.011     0.001    -0.011    -0.007    -0.028
    0.000     0.011
ELEMENTAL COMPOSITION DATA ARE BASED ON SAMPLE
COLLECTION ON 2 MICRON TEFLON 25MM FILTERS IN THE MRI AICRAFT.
THE SAMPLES WERE ANALYZED BY X-RAY FLOURESCENCE.

TOTAL OF   42 RECORDS IN FILE M81XRF.213
```

```
 38 RECORDS AT BEGINNING OF FILE

FORMAT: STATE-VS
PHYSICAL RECORD: 8Ø BYTES    LOGICAL RECORD: 8Ø BYTES
PROJECT: COLD WEATHER PLUME STUDY -- AIRSONDE MEASUREMENTS
ORGANIZATION: AEROVIRONMENT
TYPE OF DATA: COLD WEATHER PLUME STUDY -- AIRSONDE DATA
FILENAME: AV81AS.213    DATE OF DATA COLLECTION:  2/13/81
DELTA T:    VALUE =  Ø    UNITS CODE = Ø
NO. OF PARAMETERS PER RECORD:   7
DATA RECORD FORMAT: (2(F8.Ø,X),3(F9.1,X),2(F8.Ø,X),14X)
PARAMETER NAMES
DATE      TIME      ALT.      TEMP      RH        LONG.     LAT.
PARAMETER UNITS
MMDDYY    HHMMSS    METER     DEG. C    %         DDDMMSS   DDDMMSS
DATA MINIMA
  21281.  1215ØØ.       Ø.Ø     -2Ø.Ø       Ø.Ø       Ø.        Ø.
DATA MAXIMA
  22Ø81.  14ØØØØ.    25ØØ.Ø      5Ø.Ø     1ØØ.Ø     18Ø.      9Ø.
PLOT MINIMA
  21281.  1215ØØ.       Ø.Ø     -15.Ø       Ø.Ø      88.      39.
PLOT MAXIMA
  22Ø81.  14ØØØØ.    25ØØ.Ø      15.Ø     1ØØ.Ø      9Ø.      41.
NO. OF SUBFILES:    9
&&END OF MAIN HEADER
SUBFILE  1
LOCATION OF OBSERVATION (NAME, LAT, LONG, ELEV)
                    NAME: MOUNT PULASKI, ILL
       INITIAL POSITION:  Ø.4ØØ1ØØØE+Ø6N  Ø.89164ØØE+Ø6W  Ø.181ØØØØE+Ø3 M MSL
         FINAL POSITION:  Ø.4ØØ1ØØØE+Ø6N  Ø.89164ØØE+Ø6W  Ø.181ØØØØE+Ø3 M MSL
TIME OF OBSERVATION
                    DATE:  2/13/81
                    TIME:  838ØØ
NO. OF SUBFILE DATA RECORDS:         26
  21381.   838ØØ.     19Ø.Ø -999ØØ1.Ø -999ØØ1.Ø  89Ø95Ø.  4ØØØ36.
  21381.   83824.     213.1     -1Ø.8 -999ØØ1.Ø  89Ø95Ø.  4ØØØ36.
  21381.   83848.     279.8      -9.8 -999ØØ1.Ø  89Ø95Ø.  4ØØØ36.
  21381.   83912.     334.5      -7.Ø -999ØØ1.Ø  89Ø95Ø.  4ØØØ36.
  21381.   83936.     39Ø.8      -6.Ø -999ØØ1.Ø  89Ø95Ø.  4ØØØ36.
  21381.   84ØØØ.     447.7      -4.8 -999ØØ1.Ø  89Ø95Ø.  4ØØØ36.


 1Ø RECORDS AT END OF FILE

  21381.  164348.     42Ø.Ø      -4.1      34.1  89Ø95Ø.  4ØØØ36.
  21381.  164415.     482.Ø      -2.5       9.8  89Ø95Ø.  4ØØØ36.
  21381.  164442.     548.9      -1.6       7.7  89Ø95Ø.  4ØØØ36.
  21381.  1645Ø9.     614.Ø      -1.1       5.1  89Ø95Ø.  4ØØØ36.
  21381.  164536.     676.5      -Ø.8       2.Ø  89Ø95Ø.  4ØØØ36.
  21381.  164845.    1145.2      -1.1       3.2  89Ø95Ø.  4ØØØ36.
OTHER INFORMATION RELEVANT TO SUBFILE  9
@@END OF SUBFILE  9
&&
FILE CREATION DATE: 24-FEB-84    CREATING PROGRAM: AVVS


TOTAL OF  311 RECORDS IN FILE AV81AS.213
```

```
 38 RECORDS AT BEGINNING OF FILE

FORMAT: STATE-VS
PHYSICAL RECORD: 80 BYTES    LOGICAL RECORD: 80 BYTES
PROJECT: COLD WEATHER PLUME STUDY -- PIBAL MEASUREMENTS
ORGANIZATION: AEROVIRONMENT
TYPE OF DATA: COLD WEATHER PLUME STUDY -- PIBAL DATA
FILENAME: AV81PI.213    DATE OF DATA COLLECTION:  2/13/81
DELTA T:    VALUE =  0    UNITS CODE = 0
NO. OF PARAMETERS PER RECORD:   7
DATA RECORD FORMAT: (2(F8.0,X),F9.1,X,F8.0,X,F9.1,X,2(F8.0,X),15X)
PARAMETER NAMES
DATE      TIME      ALT.      WD        WS        LONG.     LAT.
PARAMETER UNITS
MMDDYY    HHMMSS    METER     DEG.      M/S       DDDMMSS   DDDMMSS
DATA MINIMA
  21281.  121500.       0.0       0.       0.0       0.        0.
DATA MAXIMA
  22081.  140000.    2500.0     360.      50.0     180.       90.
PLOT MINIMA
  21281.  121500.       0.0       0.       0.0      88.       39.
PLOT MAXIMA
  22081.  140000.    2500.0     360.      25.0      90.       41.
NO. OF SUBFILES:    8
&&END OF MAIN HEADER
SUBFILE  1
LOCATION OF OBSERVATION (NAME, LAT, LONG, ELEV)
                    NAME: MOUNT PULASKI, ILL
       INITIAL POSITION:  0.4001000E+06N  0.8916400E+06W  0.1810000E+03 M MSL
         FINAL POSITION:  0.4001000E+06N  0.8916400E+06W  0.1810000E+03 M MSL
TIME OF OBSERVATION
                    DATE:  2/13/81
                    TIME:  83830
NO. OF SUBFILE DATA RECORDS:         15
  21381.   83830.     268.0     193.       8.6  890950.  400036.
  21381.   83900.     344.0     205.       6.6  890950.  400036.
  21381.   83930.     415.0     213.       4.8  890950.  400036.
  21381.   84000.     484.0     191.       4.9  890950.  400036.
  21381.   84030.     552.0     191.       6.3  890950.  400036.
  21381.   84100.     620.0     198.       6.9  890950.  400036.


 10 RECORDS AT END OF FILE

  21381.  164630.     834.0     229.      13.2  890950.  400036.
  21381.  164700.     906.0     229.      13.2  890950.  400036.
  21381.  164730.     979.0     227.      13.4  890950.  400036.
  21381.  164800.    1051.0     229.      12.6  890950.  400036.
  21381.  164830.    1124.0     229.      11.8  890950.  400036.
  21381.  164900.    1197.0     226.      11.6  890950.  400036.
OTHER INFORMATION RELEVANT TO SUBFILE  8
@@END OF SUBFILE  8
&&
FILE CREATION DATE: 24-FEB-84    CREATING PROGRAM: AVVS


TOTAL OF  282 RECORDS IN FILE AV81PI.213
```

```
 33 RECORDS AT BEGINNING OF FILE

FORMAT: STATE-VS
PHYSICAL RECORD: 8Ø BYTES    LOGICAL RECORD: 8Ø BYTES
PROJECT: COLD WEATHER PLUME STUDY  T-SONDE DATA  FEB 1981
ORGANIZATION: ROCKWELL INTERNATIONAL
TYPE OF DATA: SUPPLEMENTAL TSOND DATA FEB81
FILENAME: R81VS.213    DATE OF DATA COLLECTION: Ø2/13/81
DELTA T:    VALUE =  Ø    UNITS CODE = Ø
NO. OF PARAMETERS PER RECORD:   4
DATA RECORD FORMAT: (4E1Ø.4)
PARAMETER NAMES
TSOND HT  TSOND WD  TSOND WS  TSONDTMP
PARAMETER UNITS
M         DEGREES   M/S       K
DATA MINIMA
Ø.ØØØØE+ØØØ.161ØE+Ø3Ø.27ØØE+Ø1Ø.26Ø7E+Ø3
DATA MAXIMA
Ø.163ØE+Ø4Ø.273ØE+Ø3Ø.154ØE+Ø2Ø.2754E+Ø3
PLOT MINIMA
Ø.ØØØØE+ØØØ.2ØØØE+Ø2Ø.1ØØØE+Ø1Ø.25ØØE+Ø3
PLOT MAXIMA
Ø.2ØØØE+Ø4Ø.4ØØØE+Ø3Ø.3ØØØE+Ø2Ø.29ØØE+Ø3
NO. OF SUBFILES:    9
&&END OF MAIN HEADER
SUBFILE  1
LOCATION OF OBSERVATION (NAME, LAT, LONG, ELEV)
                    NAME: KINCAID ILLINOIS PLANT
       INITIAL POSITION:  Ø.39353ØØE+Ø6N  Ø.89293ØØE+Ø6W  Ø.2ØØØØØØE+Ø3 M MSL
         FINAL POSITION:  Ø.39353ØØE+Ø6N  Ø.89293ØØE+Ø6W  Ø.2ØØØØØØE+Ø3 M MSL
TIME OF OBSERVATION
                    DATE: Ø2/13/81
                    TIME:  5ØØØØ
NO. OF SUBFILE DATA RECORDS:         13
Ø.ØØØØE+ØØ-.995ØE+Ø3-.995ØE+Ø3Ø.26Ø7E+Ø3


 15 RECORDS AT END OF FILE

Ø.137ØE+Ø4Ø.222ØE+Ø3Ø.87ØØE+Ø1Ø.273ØE+Ø3
Ø.146ØE+Ø4Ø.22ØØE+Ø3Ø.94ØØE+Ø1Ø.2732E+Ø3
Ø.1541E+Ø4Ø.222ØE+Ø3Ø.79ØØE+Ø1Ø.2731E+Ø3
OTHER INFORMATION RELEVANT TO SUBFILE  9
@@END OF SUBFILE  9
&&
FILE CREATION DATE: 23-FEB-84    CREATING PROGRAM: ROCKVS
COLD WEATHER PLUME STUDY, KINCAID ILLINOIS PLANT, T-SONDE DATA FOR CENTRAL SITE,
COLLECTED ON Ø2/13/81.  DATA FOR 9 SEPARATE LAUNCHINGS ON THIS DATE ARE IN
SEPARATE SUBFILES.  THE TIMES FOR EACH LAUNCHING ARE AS FOLLOWS-
 Ø5ØØ  Ø645  Ø8Ø4  Ø916  1Ø19  1117  1343  1446  1552    CST
ORIGINAL DATA TAPE FOR THIS INTENSIVE STUDY PERIOD PREPARED BY ALAN JONCICH OF
ROCKWELL INTERNATIONAL, PHONE 8Ø5-498-6771.  STATE FORMATTED TAPE PREPARED AT
WASHINGTON UNIVERSITY SPECIAL STUDIES DATA CENTER.
THE VALUE -995 IS USED TO DENOTE INVALIDATED DATA.


TOTAL OF  313 RECORDS IN FILE R81VS.213
```

```
 22 RECORDS AT BEGINNING OF FILE

20   5  38  R81MET.213  02/13/81      5. MINUTES
CWPS 1981                        ROCKWELL  MET DATA AT KINKAID
(1F10.0,7F10.3,/,8F10.3,/,8F10.3,/,8F10.3,/,6F10.3,20X)
TIME CST  WS 10M    WS 30M    WS 50M    WS 100M   TEMP010M  TEMP050M  TEMP100M
DT10-50M  DT10-100  TDP       P         NI RAD    NET RAD   DIF RAD   PRECIP
RMGST     T10MTOW   DTZ-10M   WD 10M    WD 30M    WD 50M    WD 100M   SGWD010M
SGWD030M  SGWD050M  SGWD100M  V GILL    W GILL    WS GILL   WD GILL   UV GILL
UW GILL   VW GILL   SGU GILL  SGV GILL  SGW GILL  RH
HHMMSS    M/S       M/S       M/S       M/S       K         K         K
K         K         K         MILLIBAR  WATTS/M2  WATTS/M2  WATTS/M2  MM
K         K         K         DEGREES   DEGREES   DEGREES   DEGREES   DEGREES
DEGREES   DEGREES   DEGREES   M/S       M/S       M/S       DEGREES   M2/S2
M2/S2     M2/S2     M/S       M/S       M/S       PERCENT
       288
   236000.     5.857    10.900  -999.000    13.370   349.100   360.500   363.700
    14.670     1.459   264.400  2037.000  -999.000   151.000   149.400     0.000
   273.900   271.600     4.970   206.800   198.900  -999.000   217.600     6.073
     4.958     0.000     3.225    10.850    -0.640    10.900   179.600  -999.000
  -999.000  -999.000  -999.000  -999.000  -999.000     0.363
        0.     1.343     4.061  -999.000     4.951   349.000   357.800   363.600
     8.776    14.580   259.300  1017.000  -999.000   -96.960     1.340     0.000
   259.600   257.800    -0.691     1.340   145.300  -999.000   151.500     2.748


 18 RECORDS AT END OF FILE

   263.200   262.400     1.668   144.800   151.000  -999.000   167.400  -999.000
     1.087     0.000     0.351    10.610    -1.147    10.680  -999.000  -999.000
  -999.000  -999.000  -999.000  -999.000  -999.000  -999.000
   235500.     2.054     6.406  -999.000    11.430  -999.000  -999.000  -999.000
  -999.000  -999.000   263.300  1018.000  -999.000   -38.260     3.508     0.000
   262.000   262.300     1.628   147.600   153.700  -999.000   169.600  -999.000
     2.116     0.000     0.731    10.850    -1.004    10.900  -999.000  -999.000
  -999.000  -999.000  -999.000  -999.000  -999.000  -999.000
 COLD WEATHER PLUME STUDY,KINCAID ILLINOIS PLANT,
 METEOROLOGICAL DATA FOR CENTRAL SITE, COLLECTED FROM
 02/09/81 THRU 02/22/81.  ORIGINAL DATA TAPE FOR
 THIS INTENSIVE STUDY PERIOD PREPARED BY ALAN
 JONCICH OF ROCKWELL INTERNATIONAL, PHONE
 805-498-6771.  STATE FORMATTED TAPE PREPARED AT WU/EPA SPECIAL
 STUDIES DATA CENTER.  THESE MET DATA WERE COLLECTED FROM TWO
 MET TOWERS (10M AND 100M)  AND AT A SURFACE SITE.
 FOR DETAILS, REFER TO CWPS REPORTS OF WU (GILLANI ET AL, 1985) AND
 OF BATTELLE COLUMBUS (1983).


TOTAL OF 1474 RECORDS IN FILE R81MET.213
```

12 RECORDS AT BEGINNING OF FILE

```
20   2   9  R81NWS.213  02/13/81     1. HOURS
CWPS 1981                      ROCKWELL  NWS SURFACE STATION DATA
(F8.0,8F9.2)
TIME CST  NWS PRES  NWS TEMP  NWS DP    NWS WD    NWS WS    NWS CH    NWS CC
NWS PREC
HHMMSS    MILLIBAR  K         K         DEGREES   M/S       M         TENTHS
MM
        24
 236000.  1044.00   273.70    26.87   190.00     7.72 33000.00     1.00      0.00
      0.  1040.00   262.60   259.30   160.00     3.09 33000.00     0.00      0.00
      0.  1042.00   263.70   260.40   180.00     6.69 33000.00     0.00      0.00
  10000.  1043.00   263.10   259.30   180.00     5.66 33000.00     0.00      0.00

 17 RECORDS AT END OF FILE

 180000.  1041.00   270.90   266.50   160.00     4.11 33000.00     1.00      0.00
 190000.  1041.00   270.90   267.60   170.00     3.09 33000.00     1.00      0.00
 200000.  1041.00   269.80   267.60   170.00     3.60 33000.00     0.00      0.00
 210000.  1040.00   269.30   267.00   160.00     4.11 33000.00     0.00      0.00
 220000.  1040.00   268.70   264.80   160.00     5.14 33000.00     0.00      0.00
 230000.  1040.00   268.70   265.90   170.00     3.09 33000.00     0.00      0.00
 COLD WEATHER PLUME STUDY,KINCAID ILLINOIS PLANT,
 NATIONAL WEATHER SERVICE DATA FOR SPRINGFIELD, IL, COLLECTED FROM
 02/09/81 THRU 02/22/81.  ORIGINAL DATA TAPE FOR
 THIS INTENSIVE STUDY PERIOD PREPARED BY ALAN
 JONCICH OF ROCKWELL INTERNATIONAL, PHONE
 805-498-6771.  STATE FORMATTED TAPE PREPARED BY
 WU/EPA SPECIAL STUDIES CENTER.

 DP = DEW POINT TEMPERATURE
 WD/WS = WIND DIRECTION AND SPEED
 CH/CC = CLOUD BASE HEIGHT AND CLOUD COVER

TOTAL OF   45 RECORDS IN FILE R81NWS.213
```

12 RECORDS AT BEGINNING OF FILE

```
20   1   6  R81STK.213  02/13/81     5. MINUTES
CWPS 1931                          ROCKWELL  STACK SAMPLING DATA
(6F10.2,20X)
TIME       STCK SO2   STCK NO    STCK O2    STCK VEL   STCK TMP
HHMMSS     PPM        PPM        PPM        M/S        K
       288
 236000.00    1836.00    593.00    119.00     22.00     388.00
      0.00    1518.00    436.00    103.00     18.00     379.00
      0.00    1637.00    477.00    114.00     19.00     379.00
    500.00    1611.00    473.00    114.00     19.00     379.00
   1000.00    1617.00    471.00    113.00     19.00     380.00
   1500.00    1658.00    495.00    110.00     18.00     380.00
```

15 RECORDS AT END OF FILE

```
 232500.00    1643.00    533.00    112.00     21.00     384.00
 233000.00    1666.00    549.00    111.00     21.00     384.00
 233500.00    1704.00    565.00    109.00     20.00     385.00
 234000.00    1704.00    569.00    110.00     20.00     386.00
 234500.00    1669.00    549.00    111.00     21.00     386.00
 235000.00    1666.00    543.00    111.00     21.00     386.00
 235500.00    1652.00    535.00    112.00     21.00     386.00
COLD WEATHER PLUME STUDY,KINCAID ILLINOIS PLANT,
STACK DATA FOR CENTRAL SITE, COLLECTED FROM
02/09/81 THRU 02/22/81.  ORIGINAL DATA TAPE FOR
THIS INTENSIVE STUDY PERIOD PREPARED BY ALAN
JONCICH OF ROCKWELL INTERNATIONAL, PHONE
805-498-6771.  STATE FORMATTED TAPE PREPARED BY
WU/EPA SPECIAL STUDIES DATA CENTER AT WASHINGTON UNIVERSITY,
2/12/85.
```

TOTAL OF 304 RECORDS IN FILE R81STK.213

```
 15 RECORDS AT BEGINNING OF FILE

2Ø   1   4  ISWS81.RAD                    1. MINUTES
CWPS 1981                          ISWS      TOTAL SOLAR RADIATION DATA
(4F1Ø.2,4ØX)
DATE       TIME       SOL ISWS  EVENT
YYMMDD     HHMMSS     W/M2      CODE
       117
 81Ø222.ØØ 24ØØØØ.ØØ   1ØØØ.ØØ      5.ØØ
 81Ø212.ØØ      Ø.ØØ      Ø.ØØ      Ø.ØØ
 81Ø212.ØØ      Ø.ØØ      Ø.ØØ      2.ØØ
 81Ø212.ØØ  1ØØØØ.ØØ      Ø.ØØ      2.ØØ
 81Ø212.ØØ  2ØØØØ.ØØ      Ø.ØØ      2.ØØ
 81Ø212.ØØ  3ØØØØ.ØØ      Ø.ØØ      2.ØØ
 81Ø212.ØØ  4ØØØØ.ØØ      Ø.ØØ      2.ØØ
 81Ø212.ØØ  5ØØØØ.ØØ      Ø.ØØ      2.ØØ
 81Ø212.ØØ  6ØØØØ.ØØ      Ø.ØØ      2.ØØ

 1Ø RECORDS AT END OF FILE

 81Ø22Ø.ØØ 16ØØØØ.ØØ    3Ø6.6Ø      2.ØØ
 81Ø22Ø.ØØ 17ØØØØ.ØØ    175.2Ø      2.ØØ
 81Ø22Ø.ØØ 18ØØØØ.ØØ     29.2Ø      2.ØØ
 81Ø22Ø.ØØ 19ØØØØ.ØØ      Ø.ØØ      2.ØØ
 81Ø22Ø.ØØ 2ØØØØØ.ØØ      Ø.ØØ      2.ØØ
 81Ø22Ø.ØØ 21ØØØØ.ØØ      Ø.ØØ      2.ØØ
 81Ø22Ø.ØØ 22ØØØØ.ØØ      Ø.ØØ      2.ØØ
 81Ø22Ø.ØØ 23ØØØØ.ØØ      Ø.ØØ      2.ØØ
DATA WAS OBTAINED FROM ILLINOIS STATE WATER SURVEY, CHAMPAIGN.
DATA WAS DIGITIZED FROM STRIP CHART PLOTS.

TOTAL OF  127 RECORDS IN FILE ISWS81.RAD
```

APPENDIX A2.3

Documentation of STATE-20 and STATE-VS File Formats

STATE-20 DOCUMENTATION

The STATE-20 data file format has been designed for data of a time-series form, i.e. sequential data records, each consisting of a time and corresponding values of a certain number of measured variables. Most data in the STATE data base, (comprising the GDDBs of MISTT, TPS, PEPE/NEROS, and CWPS) are of this form. Hence, STATE-20 is the most predominant data file format in these GDDBs.

File Format

The entire file is written in fixed 80-character card images (logical records). Each file has the following overall structure:

HEADER SECTION
DATA SECTION
COMMENTS SECTION
EOF (End of File mark)

The *comments section* consists of an arbitrary number of logical records with literal information of an elucidatory nature -- who, what, when, where, why, how, problems, quality assessment, exceptions, definitions, etc. It includes, in particular, definitions of data variables whose names are not self-explanatory. The comments section starts immediately following the data section. No separation markers or records exist. The start of the data section and its length, however, are predefined. The end of the comments is followed by an end-of-file (EOF) marker.

The *data section* contains the actual data of the measured variables, grouped into individual repeated observations. Each observation consists of one set of values of the measured variables (including date and time of the observation). Observations are sequential and chronological, and they all have the same format since the same variables are repeated in each observation. This observation format is a predefined syntactically correct FORTRAN format incorporating several 80-character records in one observation.

The *header section* contains important information which self-documents the file format and contents. It defines the number of variables (NVAR) and the number of 80-character logical records (NREC) in each observation; it identifies the data variables by their assigned names, and gives the specific FORTRAN format of each observation of data; and it gives the averaging time of the observation (i.e. the inter-observation time interval for continuous data) and the overall size of the data section, i.e. the total number of observations (NOBS) in the data section.

The detailed record-by-record documentation of the file is as follows:

<u>Header Records</u> (Logical H1, H2, ...)

H1: Content - NVERSION, NREC, NVAR, FILENAME, DATEC, DELTAT, UNITDT

Column(s) -	1-2	5-6	7-10	13-22	25-32	35-39	41-48
Format -	I2	I2	I2	10A1*	8A1	F5.0	8A1*

(* = left justified)

Definitions -

NVERSION = 20 = current version of this STATE format

NREC = number of 80-character logical records per observation

NVAR = number of variables in one observation

FILENAME = FFFFFF.XXX

FFFFFF = any upto-6-character alphanumeric filename, starting in column 13. Usually, this name has the form OOOOyy, where OOOO is an identifier of organization/platform collecting data, and yy denotes year of data collection. Examples: MRI75, WU76, NASA80, UVDIAL

.XXX = any upto-3-character alphanumeric filename extension. For dated missions, we recommend XXX to provide the date in the form mdd, where m=month (1-9 = Jan-Sept; A,B,C = Oct,Nov,Dec), and dd=day of month (1-31)

DATEC = Date of data collection, preferably in the format mm/dd/yy.

DELTAT = Time interval between successive observations, if fixed (0 for irregular intervals).

UNITDT = Unit of DELTAT (e.g. HOURS, MIN, SEC, etc.)

H2: Content - PROJECT, ORGANIZATION COLLECTING DATA, DATA DESCRIPTION

Format - (30A1, 10A1, 40A1)

H3: Data encoding format in parentheses. The format is assumed to be syntactically correct FORTRAN format with NVAR fields in F or E format (no I-format); use of X for spacing and / for line feed may be used in the format statement. Example for an observation with NVAR = 17 and NREC = 2:
(9F8.2, 8X, /, 5F7.1, 3E13.6, 6X)

H(4a, 4b, etc...as needed):
Names of the NVAR data variables, 8 per line, in (8(8A1, 2X)) format.

H(5a, 5b, etc...as needed):
Units of the NVAR variables, 8 per line, in (8(8A1, 2X)) format.

H6: Number of total data observations (NOBS) in file in I10 format.

--- End of Header Section ---

Data Records (Logical D1, D2, ...)

The total number of logical records in this section is NREC* (NOBS+2). The first 2*NREC records contain the physical upper and lower bounds of all data variables. The remaining NREC*NOBS records contain the actual data of the NOBS observations. The data section thus has the following record-by-record form:

D(1 to NREC):
Physical upper bounds of data variable values in specified FORTRAN format for any data observation

D(NREC+1 to 2*NREC):
Physical lower bounds of data variable values in observation format

D(2*NREC + 1 to NREC*[NOBS+2]):
The actual observed data in observation format.

--- End of Data Section ---

Comment Records (Logical C1, C2, ...)

C1 to Last logical record of file:

Arbitrary number of logical records with literal comments containing any useful information concerning the program, the data variables, data quality assessment, references to related reports, people to contact for help, or any other useful message for posterity.

EOF

--- End of File ---

STATE-VS DOCUMENTATION

The STATE-VS format has been designed as a complement to the currently existing STATE-20 format. STATE-20 is appropriate for time-series type data, while STATE-VS is appropriate for vertical soundings type data, e.g. pibal, radiosonde, sodar, etc.

File Format

Each file normally contains the data of all vertical soundings of a given platform (or station) for a given day. The filename has the form nnnnnn.mdd, nnnnnn= any I.D. of file (e.g. organization, type of data, etc.), and
mdd = month, day (e.g. 724=July 24)
= date of data collection
(A=October, B=November, C=December)

The overall file format is as follows:

```
FILE HEADER RECORDS
&&
                                  { subfile header records
SUBFILE 1                         { subfile data records
(for first sounding)              { subfile comment records
@@
                                  { subfile header records
SUBFILE 2                         { subfile data records
(second sounding)                 { subfile comment records
@@
   :
 SUBFILE n
   :
@@
&&
FILE COMMENT RECORDS
EOF
```

The main file header defines such specific items common to all soundings in the file as Project, Organization Collecting Data, Type of Data, Filename, Reported Data Parameters, their Units, Range, etc., Data Record Format and Size, etc. If the data are of vertical soundings, the first parameter should be the height level (altitude).

The main file comments provide any additional information common to the total data set which is judged useful, but which cannot be included in the main file header.

Each subfile contains the information pertinent to a single sounding. Subfiles must be arranged in chronological order. The subfile header specifically defines the time and location of the sounding and the number of records (height levels for a vertical sounding) in the subfile. Each data record provides a height level and the corresponding data of the measured parameters (e.g. wind speed, wind direction). The subfile is concluded by any comment records specific to this sounding.

Logical record size is fixed at 80 characters.

(a) Main File Header

The main file header defines specific minimum file information in a specific format. In the following header format description, underlined character strings are to be fixed, as indicated, and the rest of the information is variable.

Record 1: FORMAT: STATE-VS

Record 2: PHYSICAL RECORD: 80 BYTES, LOGICAL RECORD: 80 BYTES

Record 3: PROJECT: (T10,71A1)

Record 4: ORGANIZATION: (T15,66A1)

Record 5: TYPE OF DATA: (T15,66A1)

Record 6: FILENAME: (T11,nnnnnn.mdd) DATE OF DATA COLLECTION: MM/DD/YY

Record 7: DELTA T: VALUE =(T20,I3) UNITS CODE = (T39,I2)

This record provides information about time interval between soundings.

UNITS CODE = 0	indicates	interval is irregular
= 1	indicates	interval is in seconds
= 2	indicates	interval is in minutes
= 3	indicates	interval is in hours

(e.g. 3-hourly soundings defined by value = 3, code = 3).

Record 8: NO. OF PARAMETERS PER RECORD: (T30,I4)

Record 9: DATA RECORD FORMAT: (Data encoding format in parenthesis) Open parenthesis to be placed in column 21. The encoding format is assumed to contain a syntactically correct FORTRAN format specification utilizing only F, E and X format codes (no I-format please!) and "read record" slashes, suitable for decoding the data. Example: (F6.0, 2E12.4, 2F5.0, 40X)

Record 10: PARAMETER NAMES

Record 11: Logical record 11 should contain the parameter names in the format: n(8A1, 2X), n=number of parameters

Record 12: PARAMETER UNITS

Record 13: Logical record 13 should contain the parameter units in the format: n(8A1,2X), n=number of parameters.

Record 14: DATA MINIMA

Record 15: The actual or possible minimum values of the parameters in data record format

Record 16: DATA MAXIMA

The actual or possible maximum values of the parameters in data record format

Record 17: PLOT MINIMA

Record 18: Suggested lower bound values of the parameters to be used for general plotting purposes

Record 19: PLOT MAXIMA

Record 20: Suggested upper bound values of the parameters to be used for general plotting purposes.

N.B. Data min/max range should include range of valid data values, including outlier (but valid) values.

Plot min/max range would normally include normal data values (and possibly not include valid outliers).

Record 21: NO. OF SUBFILES: (T19,I3)

Record 22: && (end of Main File Header)

(b) Subfile Header

Record 1: SUBFILE (T8,I3) Sequential subfile number

Record 2: LOCATION OF OBSERVATION

Record 3: NAME: (T26,55A1) Literal name of location, if any.

Record 4: INITIAL POSITION: (T26,E14.7,2X,E14.7,2X,E14.7)
LAT LONG ELEV(m MSL)

Record 5: FINAL POSITION: (T26,E14.7,2X,E14.7,2X,E14.7)
LAT LONG ELEV

For stationary platforms (e.g. PIBAL during a single sounding), initial and final positions will be same. For a moving platform, such as an aircraft lidar making a remote vertical profile sounding, the subfile may contain an average profile measured between aircraft initial and final positions during averaging time.

Record 6: TIME OF OBSERVATION

Record 7: DATE: (T26, MM/DD/YY)

Record 8: TIME: (T26, HHMMSS)

Record 9: NO. OF SUBFILE DATA RECORDS: (T30,I10)

Record 10: Start of data records (in specified data record format)

⋮

N data records

⋮

Record 10 + N: Start of comment records (80A1 format)

@@ (End of subfile)